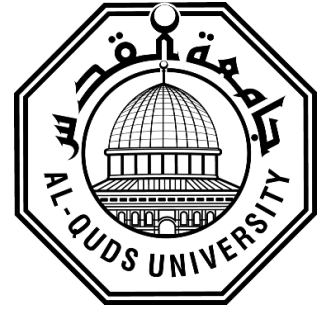


**Deanship of Graduate Studies
Al-Quds University**



**User Experience and Digitally Transformed/Converted
Emotions**

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M.Sc. Thesis

**Jerusalem – Palestine
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User Experience and Digitally Transformed/Converted Emotions

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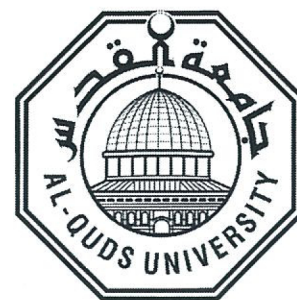
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Dedication

To Spirit of my Father, Dr. RAFAT ODEH, my ideal.

To my Mother, source of support, my best friend.

To Ammar and Ahmad my brothers.

To Rima and Hiba My sisters.

Words cannot show how much I love all of you.

Mohammad Rafat Mohammad Odeh

Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except when otherwise acknowledged, and that this study (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed

Mohammad Rafat Mohammad Odeh

Date: 14May 2017

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Abstract

Day by day, humans try to find new tools and techniques to interact with their environment. This perimeter contain humans, animals, machines etc. In human natural interaction (human-human interaction), humans use speech beside the non-verbal cues like facial expressions movements and gesture movements to express themselves. However, in (human- computer interactions), computer will use the non-verbal cues of human beings to determine the user experience and usability of any software or application on the computer.

In this thesis, we will study the human–computer interactions process in details. On the human side, people have their own way to express their emotions like satisfaction, disaffection, anger, sadness, etc. On the other side, computer which does not care about people emotions when they involving use its software or application or service.

On human side, the study explain the meaning of digitally Transformed/Converted emotions, and human behavioral cues that indicate the digital emotions.

Also, it investigates human side to figure out, what broadcasting paths of emotions are? How psychologies infer emotions? What are the methods use in infer these emotions? It discuss details of different approaches in facial expressions and handover gestures.

The study introduce a new model called Measuring User Experience using Digitally Transformed/Converted Emotions (MUDE) which measures two metrics of user experience(satisfaction and errors) , and identifies the difference between usability and user experience.

Finally, Computer side can feel user digitally transformed/converted emotions that generate during human –computer interactions process by smart Intel interactive gesture camera that captures user’s“negative and positive” emotions “digitally transformed/converted emotions” and compares them with System Usability Scale (SUS) questionnaire results by conducting an experiment for measuring the usability and user’s experience.

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List of Abbreviations

Abbreviation	Abbreviation Full Name
ADs	Action Descriptors
ANS	Automatic Nervous System
AUs	Action Units
BP	Blood pressure
BVP	Blood Volume Pulse
ECG	Electrocardiogram
EEG	Electroencephalography
EMG	Electromyogram
FA	Facial Animation
FACS	Facial Action Coding System
FAPs	Facial Animation Parameters
FAPUs	Fraction of the distance between key facial features
FDP	Face Definition Parameters
FPs	Feature Points
HR	Heart Rate
HRV	Heart Rate Variable
IBI	Inert Beat Interval
ISO	International Standards Organization
MPEG	Moving Pictures Experts Groups
MUDE	Measuring User Experience using Digital Emotions
QUIS	Questionnaire for User Interaction Satisfaction
SC	Skin Conductivity
SUS	System Usability Scale

TAM	Technology Acceptance model
3D	Three Dimensions
UPA	Usability Professionals Association
UxPA	User experience Professionals Association

1 Chapter One : Introduction

1.1 Introduction

Although modern technologies and software are designed to be accessible for all users ,they are still complicated and fail to ease users experience .Therefore ,more time and effort must be conducted on “manual usability “studies ,despite being time consuming

There are many evaluation methods and techniques used for testing user experience, in order to produce software that meet the User Experience parameters. One of the modern techniques is using facial expressions and gestures to expect the user interaction and perception of the developed software, this technique depends on user face and gestures.

Taking into consideration that human facial expressions and body gestures are very significant means of communication between people as they provide important information and help deliver peoples communicative aim. Humans learn to recognize facial expressions long before they learn to communicate verbally (Harty, 2011). Faces and gestures not only provide us with the primary source of information about the people that we are communicating with like there sex or gender, but also provide us extra communicative functions like how they manage the conversation and how they express themselves towards what is being said.

Faces and gestures are also excellent ways in a conversation for showing confirmation or surprise without saying any word. Therefore, facial expressions and gestures are the most effective way for communicating emotions of people (Harty, 2011).

1.2 Motivation

ICT revealed all aspects of human's lives. Computing devices such as cell phones, pocket-based computers, pads, pods, digital video recorders, entertainment appliances, and navigation systems have recently spread and used widely because of the decrease in hardware cost. Consumers usually focus on technologies that satisfy their specific needs, and their usability issues that they are looking for.

There are many factors that impair technology benefits, like poor quality design, and failure to observe usability issues . Sometimes the difficulty of interacting with an interface of a computing device, can be personally disturbing and socially disruptive, this may lead to rejection that contributes in technological illiteracy.

According to (Branco, 2006), in a survey of six thousand computer users, found that users wasted an average 5.1 hours per week in trying to use computers. In a similar study, nearly one-third to one-half of the time being spent in front computers was wasted due to frustrating experiences. A subsequent study conducted to determine specific causes and effects of user frustration, found that 42% of students and 58% of workplace users are being angry while using their computing devices because of a technical problems encountered during daily tasks (Branco, 2006).

Human computer interaction (HCI) or user-centered design (the old name of HCI) is a field which the developer try his best to design a user friendly system (Shah et al.2014). Branco (2006) added that observational methods were developed to capture the opinion of users, and monitor their experience to enhance the system to be more usable. It seems this task is not easy to accomplish because wide variety of users with different skills and requirements

that differ in terms of context and devices. In addition, there are economic pressures on manufactures to produce new releases in short cycles, to preserve competitive advantage, which increase and complicate problems. This results in negligence of ill designed HCI as well as lack of end user consideration and support at runtime.

To manage the previously mentioned obstacles, there should be work on how to capture the users experience in environment with no constraints (live environment), that is while they are performing activities. The important issue is how we can proceed quickly without being too instructive, and without asking or forcing the users to explicitly state the problems, hence, diverting from the goal of diagnosing and resolving the problem?.

Another point is how can we realize the human–computer interacting dialogue to software and hardware manufacturers to improve their products and take into consideration negative issues in their future designs?

There are various approaches that may be applied to solve the above mentioned issues. The path followed in this work, explores the notion of measuring usability, and recognizing user difficulties in habitual computer environment using emotions that can be captured from human facial expression and gestures.

The next sections will explain the used approach.

1.2 Problem Statement

Despite the widespread usage of interfaces and the increasing usability evaluation, there is only one instrument to observe and to monitor the user experience in a usability laboratory with certain constraints.

In order to make an ideal usability evaluation scenario, study must be unconditional and realistic observation for a long period of time are needed, these requirements match the regular usability-testing environment in which we extend the observation methodology to be performed remotely presents many difficulties.

Data collection in constrain environment is hard (Branco, 2006). A large pool of users means large data collection, transmission and analysis to identifying interaction problems (Branco, 2006).So, an alternative approach with self-report usability mechanism is needed .This approach provides data comparable to usability experts (Hartson et al. 1996). Windows (operating system) deals with system failure (e.g. system crash) with user's feedback strategy .the same procedure won't work for usability software as it doesn't have a clear indication of the problem. Therefore, the question is: How to detect occurrence of the problems and critical incidents in usability software ?.

1.3 Methodology

Nonverbal communication plays a central role in human–human dialogue and interaction. In one hand, the ability to read nonverbal cues is essential to understand, analyze and predict the actions and intentions of others (Mahmoud and Robinson, 2011). In the other hand, Interrupting body language and subtle clues make us aware about others' comprehension, agreement, disagreement and emotions (Branco, 2006). These nonverbal cues or body language can be translated through face or hand over face gestures.

The face and hand over face gestures are the channels through which human could express his emotions. Between different communicative channels that express emotions, the face is often consider the richest source of nonverbal of information (Ekman, 2003). In addition, the hand over face gestures are subset of emotional body language (Mahmoud and Robinson, 2011).

Our research focuses on investigating a new approach for determining user experience indicators for any application used for any purpose. We will capture the expressed emotions either positive or negative (digitally Transformed /Converted emotions) through face

expressions and hand over face gestures while using application software, these emotions will be used to measure two parameters of user experience satisfaction and errors.

The proposed methodology is a new approach, it maps the two user experience parameter into emotions. Each one of these emotions has its specific facial expressions and specific hand over face gestures. In this way, we leave the traditional tools of usability engineering and the user is the source of information.

Body language issues and the relation between the digitally Transformed /Converted emotions and body language items like facial expression and hand over gestures will be discussed. Furthermore, there is a discussion of some methods used for extracting the emotions from body language items and the protocols that used for that.

An empirical experiment was carried out to show how the user expresses his or her emotions in critical incidents. This study use in experiment an interactive camera manufactured by Intel that reads emotions instantly (Doss and Raj,2013).

1.5 Contribution

In this research an approach to measure user experience and usability was proposed. Two parameters of usability and user experience (satisfaction and errors) were linked with their expected digital emotions that will be expressed by user while using application software. These expressed emotions have their specific facial expression and hand over face gestures. So, user emotions will be read focusing on body language. I support my work with empirical experiment showing how user express his or her positive or negative emotions in critical or easy incidents.

1.6 Thesis Organization

The rest of chapters are summarized as follow:

Chapter two discusses the human behavioral cues and their relation with emotions. In addition, we introduce some psychologist theories about emotions and its relation to brains, and I will introduce a new topic called “Digital Emotions”.

Chapter three is concerned with inferring emotions from psychological behavior and facial expression; it explains the approaches and theories that deals with inferring emotions.

Chapter four introduces a new model for inferring user experience and usability based on previous models. In addition, it discusses the user experience and usability similarities and differences.

Chapter five explain an experiment dealing with inferring emotions that indicate usability and user experience.

The final chapter (chapter six) deals with future work and limitations, also it discusses contributions and some remarks.

2 Chapter Two: Human Behavioral Cues Point Out Digitally Transformed/Converted Emotions “Literature Review”

2.1 Human Behavioral Cues Relationships

Transposing human behavioral cues are not easy tasks for specialists, as the scope of human cues (verbal and nonverbal) are extensive, human behavioral cues can be deduced from many patterns.

In this section, we will introduce a model that shows human behavioral cues and the hierarchical relationship between these cues. For example, human behavioral cues consist of human emotional cues and other behavioral cues such as yawning, grunting, sniffing, etc.

Below is a detailed structure of the model (Zhao, 2012):

- 1- Human behavioral cues: yawning, grunting, sniffing, coughing, etc.
- 2- Human emotional cues: speech that is an explicit linguistic messages, text
- 3- Nonverbal cues: physiological cues that is brain activity, heart rate, blood flow, speech that is an implicit linguistic message, e.g. pitch and reflections, sound like laughing, crying, and visual cues.
- 4- Visual cues: like tears, flush, and body language.
- 5- Body languages: like hand gestures, body postures, facial expressions, head movement, and eye gaze.

Figure (2-1) summarizes the model and shows the relationship between them:

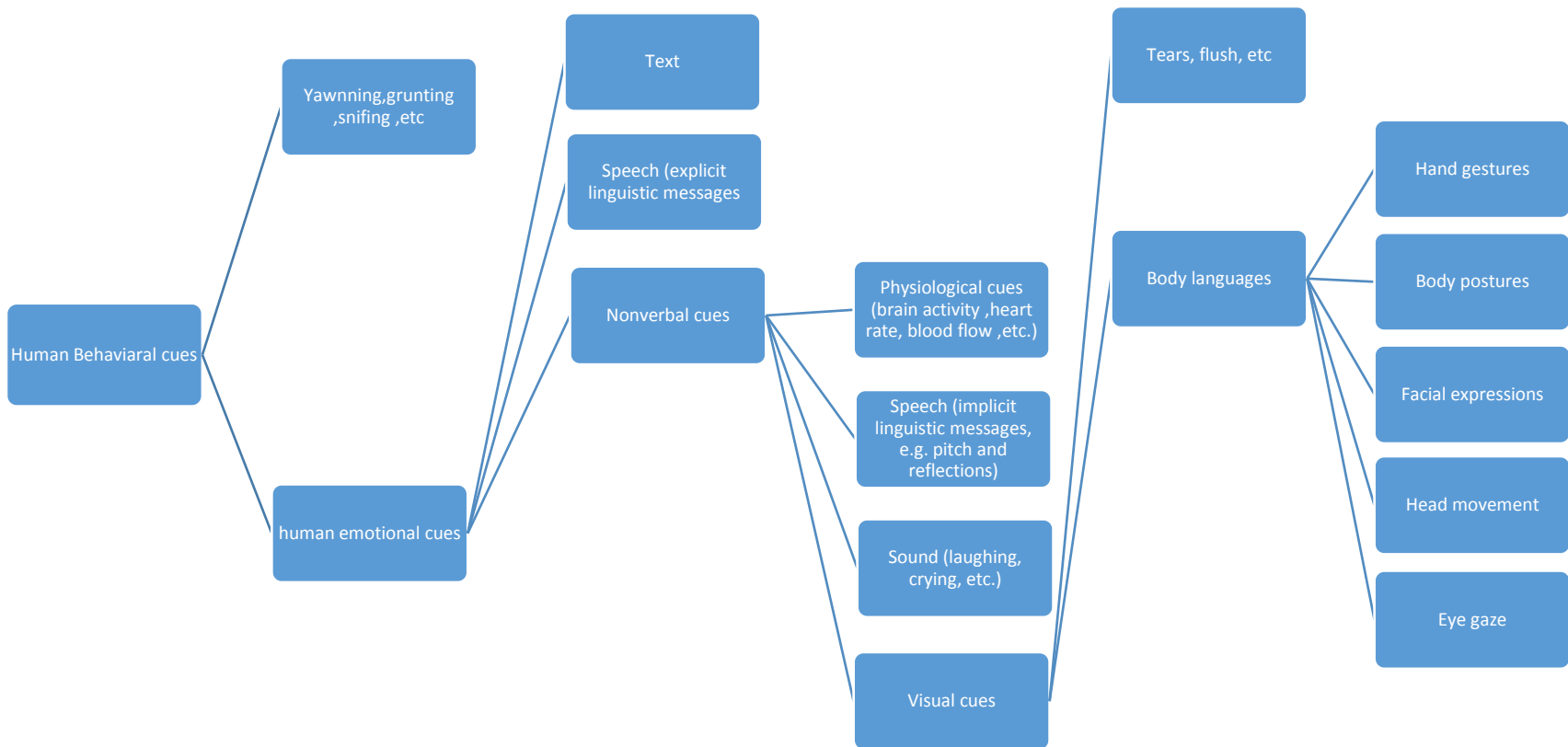


Figure (2-1): Human behavioral cues relationship diagram (Adopted from (Zhao, 2012))

2.2 Body language and hand over face gestures

In the previous section, we talked about human behavioral cues model and its component, and we mentioned that human behavioral cues consist of human emotional cues that contain visual cues including nonverbal cues that the body language is one of its types. In addition, that body language comprises of facial expressions, hand gestures and other cues. Anyway, in this section we will define body language and its components, and the role of body language in human-to-human communication.

Allan Pease in his book (the definitive book of body language) defined the body language as an outward reflection of a person's emotional condition. (Pease and Pease, 2004) confirmed that each gesture or movement can indicate a person emotional state or feeling at a specific time. However, *Hedwig Lewis* in his book (body language: A guide for professional) emphasized that body language is a communication channel accompanied by the spoken language. He defined the body language as follows: “body language is the communication of personal feelings, emotions, attitude, and thoughts through body movements like gestures, postures, and positions, also, distance consciously or involuntarily, more often subconsciously, that is accompanied by the spoken language” (Lewis, 2012).

Body language is “a type of nonverbal communication that plays a central role in how humans communicate and empathizes with each other. The ability to read nonverbal cues is essential for understanding, analyzing, and predicting the actions and intentions of others” (Mahmoud and Robinson, 2011).

Recently, there is a clear tendency from the community to understand and recognize people's affective and cognitive states, based on facial analysis. Nevertheless, the accuracy of facial analysis is limited related to hand over face gestures.

The facial expression and hand over face gestures are subset of emotional body language (Mahmoud and Robinson, 2011).

Humans from different cultures, and in various situations can communicate, and interacted with a certain level of accuracy when they observe both the face and the body (Mahmoud and Robinson, 2011).

2.3 Facial expressions

2.3.1 Brief history of facial expression

The study of facial expression and physiognomy started in 4th century BC (Bettadapura, 2012). Physiognomy is a field of knowledge that evaluate person's characters through their faces and outer appearance, year after year the physiognomy became diminishing and waning. In addition to that, facial expression has been an active topic (Highfield et al, 2009). In 1649 (17th century) *John Bulwer* mentioned in his book (*Pathomyotomia*) a note about various expressions and movements of head muscles. *Le Brun* (French academician and painter) at Royal Academy of Painting in 1667 presented a lecture pertaining facial expressions that was reproduced in a book in 1734.

Many actors and artists read his book in 18th century (Bettadapura, 2012); they tried to get the imitation of facial expression. *Charles Darwin* did the most important work in 19th century. He wrote an article about expressions and the meaning of expressions in both human and animal (Darwin, 1872). He also categorized the different expressions in groups, and cataloged the facial shapes with expressions groups. Starting with 70s *Paul Ekman* and his colleagues wrote many important studies had a vital influence on developing facial expression recognition.

2.3.2 Definition

The face and the facial expressions are very important network for communicating human's interactions human interacts (Branco, 2006).

The face with its facial expressions is a window for the contents of human souls like emotions. Common sense and science met together to confirm the previous fact. (Russell and Fernandez-Dols, 1997). Through face and facial expression system, we can make our emotion measurable and understandable within an evolutionary framework, with implications in medicine, the criminal justice system, education, business, and psychotherapy (Ekman and Friesen, 1975). Facial expressions deformed by the contractions of facial muscles that create temporally facial features such as eye lids, eye brows, nose, lips and skin texture, often revealed by wrinkles and bulges. The muscular activity of facial expression lasts for few seconds that is not more than 5s or less than 250ms (Fasel and Luttin, 2002).

In Darwin book “The expression of the emotions in man and animals” mentioned that some emotions have a universal facial expression, he confirmed that the movements of expression reveal thoughts and intentions of others more truly than words (Darwin,1872). *Ekman* in his study “Constants across cultures in the face and emotion,1971” introduced new idiom “facial expression recognition” that refers to the classification of facial features in one of the six so called basic emotions: happiness, sadness, fear, disgust, surprise and anger.

2.4 Digitally Transformed/Converted Emotions

2.4.1 Emotions

Emotion is an essential ingredient for human that is complex and hard to find a consensus on its definition. The emotion like joy, anger, disgust and plethora of other emotion add an active motivation and richness for human experience. (Brave and Nass, 2003)

In 1579, emotion word was adopted from the French word “*émouvoir*” which means, “to stir up”. After that emotion became a term used in academic discussions to replace passion (Wikipedia Emotions, 2015)

Many researches that defined emotion, but there is no consensus among these researches on an accepted definition. Therefore, we will explore the common aspects of emotion mentioned in one of the most important research study.

Paul and Anne Kleinginna research study (a categorized list of emotion definitions, with suggestions for consensual definition) that contains a different collection of emotion definitions, stated that emotion has two important aspects:

(a) emotion is a reaction to events related to the needs, goals, or concerns of human (b) emotion includes physiological, affective, behavioral, and cognitive component (Brave and Nass, 2003). These two general aspects are extracted from many different definitions that *Kleinginna*s have mentioned in their research study.

2.4.2 Ekman emotion characteristics

Paul Ekman in his book *Emotion Revealed* (Ekman , 2003) describe the characteristics of emotion .He sees that feeling is a collection of sensations that humans are involved in and conscious of ,while emotion is a reaction to events related to the needs ,goals or concerns of human. Short emotional event occasionally remains for seconds or few minutes like the

startle reaction or alarm reaction that happened as response for sudden unexpected stimulus such loud noise or flashlight . If it lasts for hours or even days, it is mood. The series of negative occurrences can be give a negative mood for users like angry situations that can be occur repetitively. As emotions occur, humans deal with them (response to loud noise). They are not aware of appraising unless extends for long period. The emotions that we feel are supported by refractory period (i.e. the response period for flashlight), which filters information and knowledge stored in memory and giving us access to what support the emotion we are feeling. It could remain for few seconds or minutes. They universally themes reflect evolutionary history, and culturally learned variations Humans become emotional related to their fathers. Human attitude is stimulated by the desire to experience an emotion Therefore ,Emotional status or feeling of human can be inferred by efficient, obvious, quick and universal signals .

2.4.3 *LEDOUX* neurological structure of emotion (the seat of emotion is brain)

In 1996, *LEDOUX* (neurologist) has put a model to explain the neurological structure of emotion in brain, the following figure (2-2) shows the neurological structure of emotion.

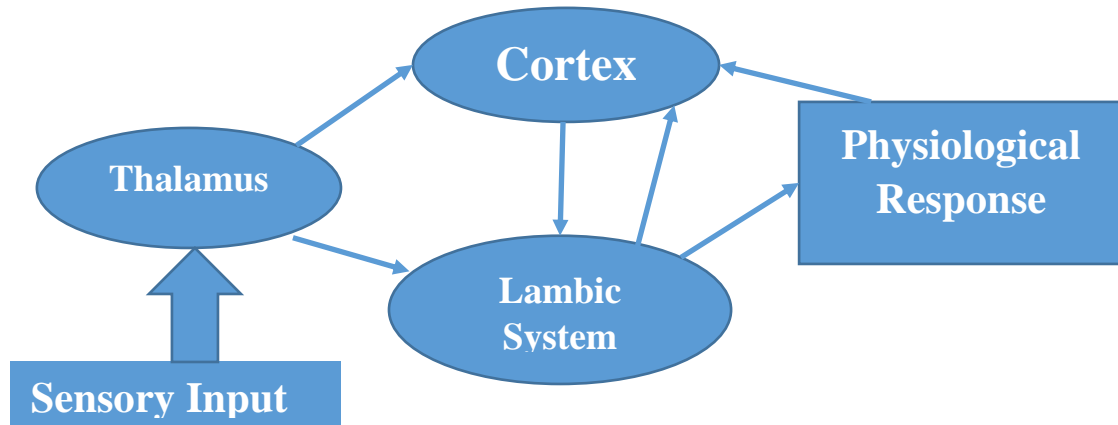


Figure (2-2): Neurological structure of emotion (Adopted from (Branco, 2006))

The above simple model contains three main component of brain (1) Thalamus (2) Limbic system and (3) cortex. Thalamus receive all input by physical senses from exterior medium and processes the signals, then sends the information simultaneously both to the cortex, which functions as high level processing, and to the “seat of emotion” limbic system, which evaluates the need and goal relevance of its input. When the relevance is determined, the limbic system sends appropriate signals to the body, coordinating the physiological response, and to the cortex, biasing the attention and other cognitive processes. (Brave and Nass, 2003).

There are two types of emotion: primary (primitive) and secondary (Damasio, 1994); The primary emotion evolved as a fast response mechanism or as innate aversions attractions.

This mechanism prepares the organism to fly or fight. Examples of primary emotion startle response that responses to sudden stimulus such as flash of light, a loud noise, or sudden appearance of pop up window (Brave and Nass, 2003).The direct thalamus –limbic pathway is the mechanism that accounts for primary emotion.

The secondary emotion are results from high level processing in cortex of stimulus from limbic system activation such as frustration, pride and satisfaction, for example, realizing the wrong file overwrite. The different neurological pathways that carry information about exterior stimuli from sensory thalamus to the limbic system can be high road or low road. The high road for secondary emotion and the low road for primary emotion or innate reactions. Figure (2-3) explains the mechanism.

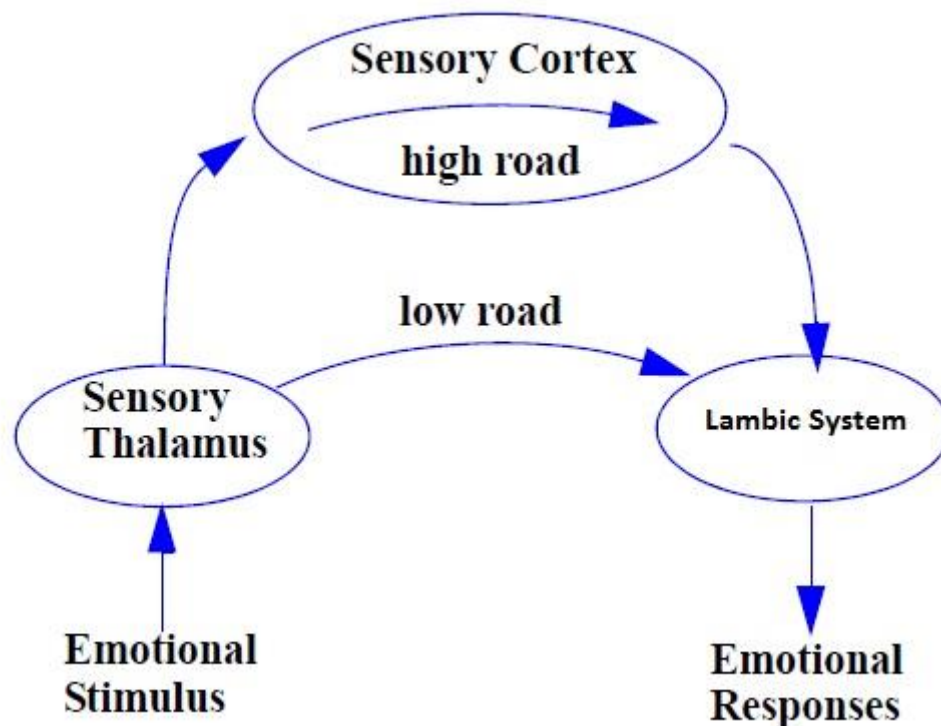


Figure (2-3): Explain the high road and low road from Thalamus sensory to Limbic system for primary and secondary emotion.(Adopted from(Branco, 2006))

2.4.4 Causes of emotion

1- Needs and goals

Emotion is a reaction that is relevant to needs and goals of human (Brave and Nass, 2003). In 2012 *Maslow* mentioned in his book (toward psychology of being) eight basic needs for human which are psychological human needs: safety and security needs, social needs, esteem needs, cognitive needs, aesthetic needs, self-actualization needs and transcendence needs. When these abstract users need achieve positive emotion results on human, these basic needs hampered to achieve the negative emotion results. The goals are instruments to achieve the human basic needs.

2- Appraisal theories

Appraisal theory in psychology relies on that emotions are generated from our evaluations of events. When Appraisal incidents occur, they produce various responses in different humans. Evaluation of an episode produces an emotional or affective reflection that directly depends on evaluation or appraisal (Wikipedia Appraisal,2015).

A clear example of this theory when a person is going to a date, and if the date is positive, the person feels happiness and joy, because he or she evaluates, like starting a new relationship, engagement, or even marriage. However, when date is negative, the emotions would be dejection, sadness, emptiness, or fear.

Appraisal theory provides a predictive power by specifying the previous episodes that lead to particular emotions (Brave and Nass, 2003).

The novelty and valance, and the level of certainty and uncertainty in incident has a huge effect on emotion experience. Uncertainty about positive incidents leads to interest, but in negative incidents leads to anxiety. In other words, the positive cases lead to relief while negative cases lead to despair. The second important issue in eliciting emotion is the obstacle

and control. Control can lead to sense of challenge in positive cases and stress in negative cases. The third factor in emotional response is the agency. Sometimes the human can be cause of shame (negative situation) or cause of pride situation (positive situation).

3- Contagion

In many cases, people catch emotions from each other's (Brave and Nass, 2003). A person laughs when he/she sees another experience laugh, this social phenomena is logical.

4- Moods and sentiments

Moods are more diffuse, global and general than emotion. Mood lasts for hours or a day not like emotions that last seconds to minutes, also moods can be indirectly triggered by particular object (Branco, 2006). Sentiment is not a state of human but it specifies properties to objects (Branco, 2006).Mood and sentiment can bias emotion; they lower the activation threshold for mood-consistent emotion.

5- Previous emotional state

Previous emotional state can affect the emotion in two ways: the first way by the mood mechanism-emotion can cause moods, moods then bias the activation thresholds of emotion. The second way is by excitation transfer mechanism and habituation. The excitation transfer is based on the truth that emotion occurrences rise stimuli, the automatic nervous system have come and gone, takes time to return to its normal state, and if another emotion is triggered before the time to return is complete, the residual activation will be added to current activation and be perceived as part of the current emotion.

2.4.5 Emotion classifications using approaches

Three approaches can classify emotions based on psychology research. These major approaches are categorical approach, dimensional approach, and appraisal approach (Grandjean et al, 2008).

- **Categorical approach**

In this approach, there exist a small number of emotions that can be universally recognized. *Ekman* in his book (Emotion in the human face, 1982) applied various experiments on human judgment of images that deliberately expressed facial expressions; it concluded that there are six basic emotions, which are universally recognized namely: happiness, sadness, surprise, fear, anger, and disgust. Some researchers suggested different number of basic emotions from 2 to 18. *Ekman's* theory on universal nonverbal emotional expression of the six basic categories has been the most commonly adopted approach.

Some researchers have explored cognitive states that are used in daily life like *Baron Cohen* and his colleagues. The disadvantage of the categorical method is that each emotional display is classified to a single category, therefore emotional states or secondary emotions will be too difficult to determine (Zhao, 2012).

- **Dimensional approach**

According to this approach, the emotional states are related to each other in a systemic manner. Three dimensions describe the emotional variability: valence, arousal, and power. The first dimension is valence for positive or negative degree of the emotion; the range is from unpleasant feelings to pleasant feeling. The second dimension is about how excited the emotion is, it ranges from boredom to frantic excitement. The third dimension is the degree of power or sense of control over emotion. The following figure explains the proposed emotional space consisting of four quadrants: low arousal positive, high arousal positive,

low arousal negative and high arousal negative. According to the differences of the valence and arousal, emotions can be distinguished and plotted on the two dimensional place (Zhao, 2012).

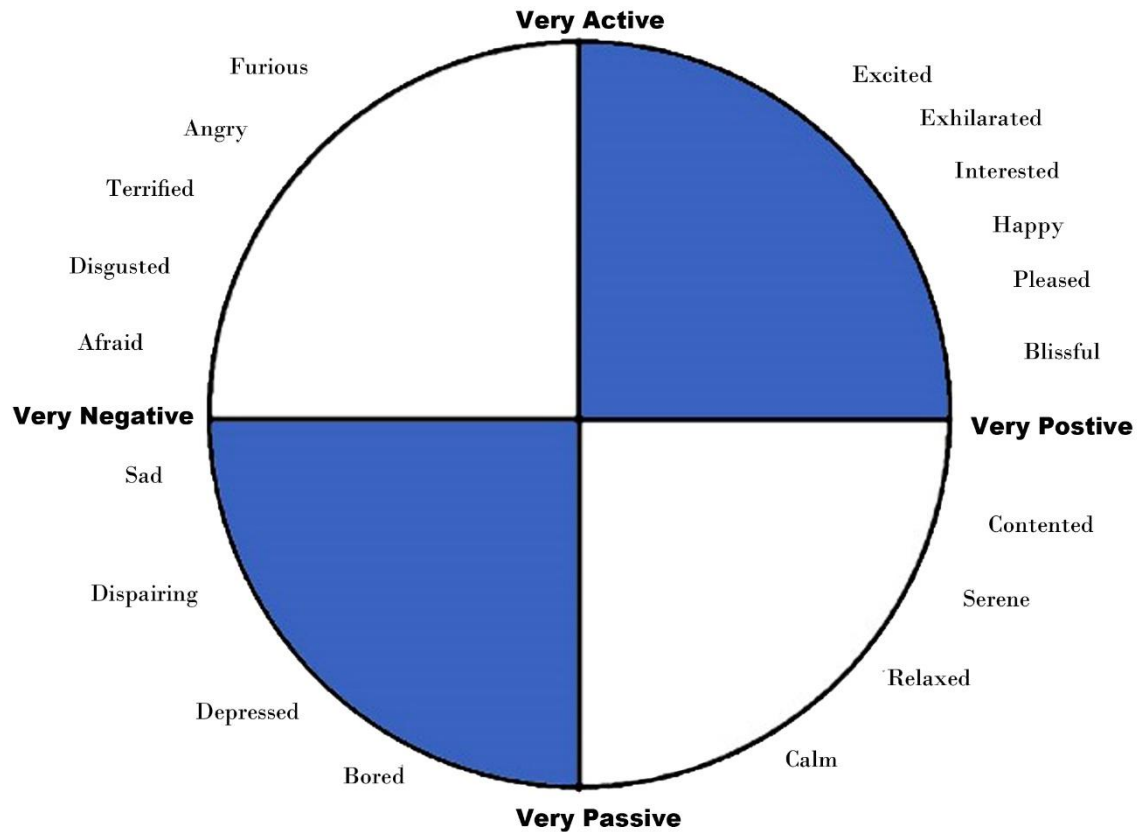


Figure (2-4): Dimensional approach (Adopted from (Zhao, 2012)).

This approach has its advantages and disadvantages. The first advantage of this approach is that observers can designate their intuition for each stimulus on several continuous scales; second advantage is that this approach challenged the emotion theorists who have mentioned that the reduction of emotion space to two or three dimensions is reductive and results in loss of information. The third advantage is that the basic facial expressions of *Ekman* such as happiness or sadness can be easily distinguished in dimensional space. There are disadvantage of this approach like some *Ekman* facial expressions such as fear and anger which are not easily distinguished, and some facial expression exists outside the dimensional

space, also it is unclear how to distinguish the position of some cognitive states like confusion on the space.

- **Appraisal approach**

This approach is an expansion of the dimensional approach. It distinguishes emotion based on the interpretations of incidents far away from emotions causes. This approach explores emotions neglecting the modifications that occur in the related aspects like cognition, physiological reactions, motivation, feelings, etc. The advantage of this approach is that there is no specific number of emotions with distinct classes or dimensions. Emotions can be characterized by “stimulus evaluation checks, including novelty, compatibility with standards, intrinsic pleasantness and goal-based significance”.

2.4.6 Digitally Transformed/Converted Emotions

Emotion is an effective state involving a high level of activation, intuitive changes and strong feeling (Biyaye, 2009). These emotions appear in different situations that human can be exposed to. In human–human interaction, there are emotions that appear in this interaction like stratification, anger, contempt, and so on. However, in human-computer interaction, are there any emotions exposed?

Many emotions appear on human face and body; these emotions are translated through body language, facial expressions and gestures. We differentiate these emotions and call them digitally transformed/converted emotions. Emotions resulting from the interaction of human with PC, pocket, smart phone, or any computer device is digitally transformed/converted emotions. These digitally transformed/converted emotions carry the same aspects and characteristics of regular emotions, and we can measure them using the same tools in regular emotions that result from human–human interaction.

2.5 Discussion

The main objective in this chapter is to focus on the relations connecting the emotions with body language that includes facial expressions and gestures. This hidden relation gives the researchers the opportunity to investigate the affect state of human who uses computer device without explicitly communicating with it. Personally think that reading of nonverbal cues of user, makes the evaluation operation of any application more efficient and more accurate while it decreases annoyance to the user. The emotions or digitally transformed/converted emotions that result from the human–computer interactions have the same characteristics and aspects of emotions that results from human–human interactions, and we can use the same category approaches of emotions to implement them on digitally transformed/converted emotions. Therefore, methods for monitoring these digitally transformed/converted emotions can be developed and hence using these digitally transformed/converted emotions in measuring the usability of applications. Digitally transformed/converted emotions can be a good and a clear indicator to usability of any application. *Mehdi Bayayi* indicated in his Thesis Nonverbal emotional dictionary (Bayayi, 2009): “We learn how to communicate with facial expressions long before learning to speak and using words and sentences. The human face is in continuous motion and is therefore it is a very important way of communication between humans. Facial expressions are very efficient in providing background information about the mood of the person while we are talking to him and inferring what this person is really trying to say. For example we often shake the head vertically as a sign of confirmation and horizontally as a sign of disagreement and we also use facial Expressions to draw the attention of the person we want to talk.”

3 Chapter Three : Methods for inferring emotions “Literature Review”

3.1 Introduction

As we have shown in the previous Chapter , there are exciters for emotions like needs and goals, these exciters generate emotions that affect human’s behavior; the results of the exciters “emotions” will be clearly reflected human face and body language.

To explain how these exciters work let us take the following scenario, a user utilizes a computer hoping to achieve a specific goal like sending an email, the user will make specific steps to achieve his goal: he will log into his email account, then composes a new email, finally send the email. If the user accomplishes his mission and sends the email, he will be very happy, but if he fails in any of the steps, he will be very sad and maybe anger. We can see the effects of success or failure on user face and on his body language, and we will be able to understand the emotional status of the user from his facial expressions (happy or angry face).

The ability to recognize others’ behaviors through emotional states is essential in social interaction. In contrast, in human-computer interaction the computer does not care about variable emotional state of the user (Branco, 2006). The external appearance of a user is a result of psychological behavior associated with particular psychological state caused by the nervous system. In this chapter, we will explain the broadcasting paths of these emotions. In addition, methods for capturing these emotions.

3.2 Emotions Broadcasting Paths

There are specific channels especially in HCI that detect emotion cues that the researcher can use for inferring emotions. Researchers can detect emotion from the following modalities: facial expressions, audio (voice), body postures, physiological information, text, and multimodal cues (Zhao, 2012). The following figure is a structure model that explains the emotions Broadcasting Paths that researchers used.

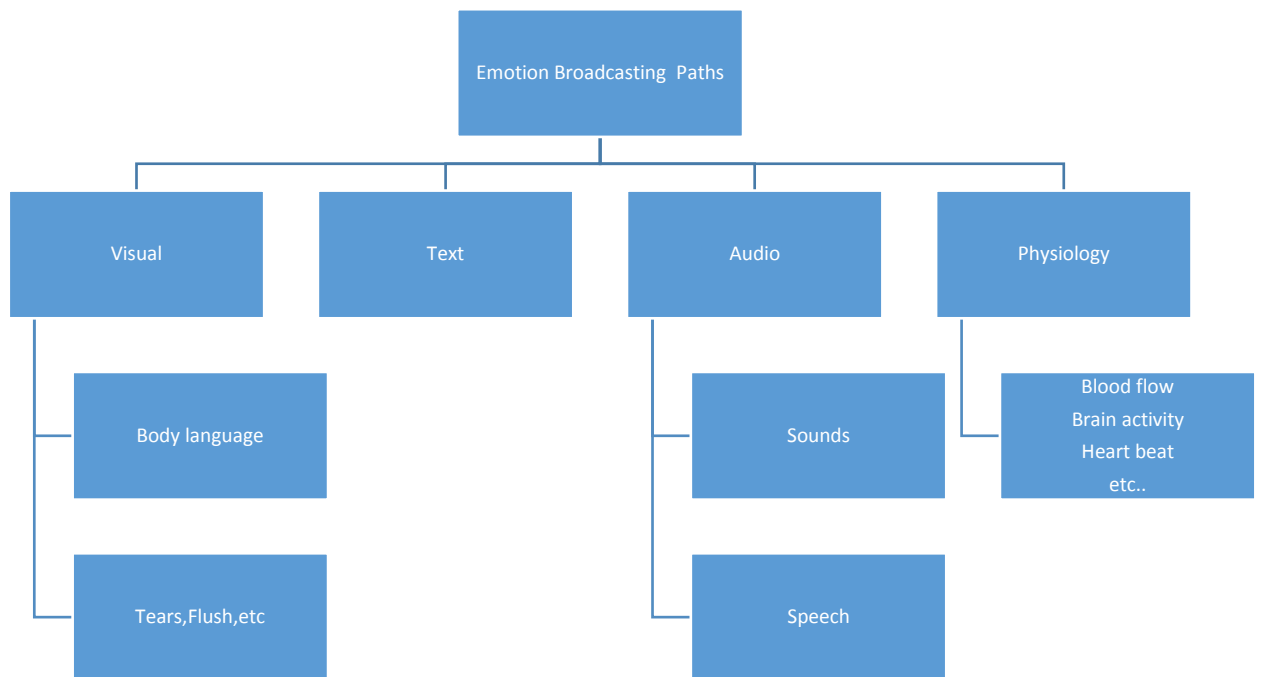


Figure (3-5): Emotions Broadcasting Paths for Researchers (Adopted from (Zhao, 2012)).

3.3 Inferring emotions from the psychological behavior

The automatic nervous system (ANS) is the controller of psychological responses (Branco, 2006). When emotion exacerbate the activation of (ANS) is changed (Zhao, 2012). Emotional broadcasting paths like facial expression and body postures provide us with visible changes in emotion status; also, there are invisible changes that will happen in bio-signals such as heart contraction force and rate, sweat gland activity, skin temperature reaction etc. *John Andreassi* in his book (*Human behavior and Physiological response*, 2000) introduced a sketch that explains how the nervous system controls the physiological response. The following figure (3-6) is *Andreassi* sketch.

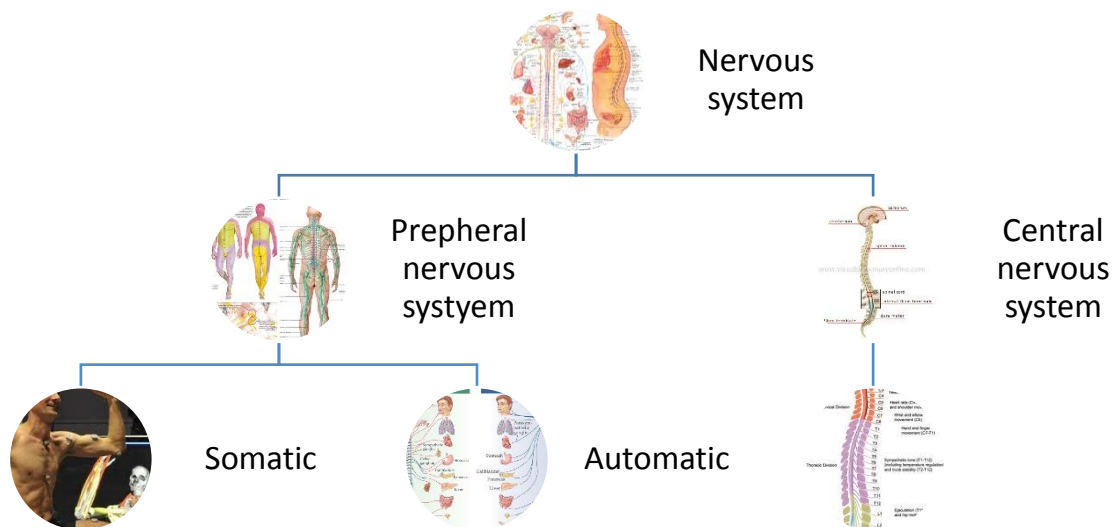


Figure (3-6): How nervous system controls physiological responses(Adopted from (Andreassi, 2000))

There are signals that are usually referred to as physiological or bio-signals that can be used in emotion sensing in research field for identifying emotions, are listed in the following table (3-1).

Table (3-1): Physiological or Bio-signals tools

Bio-signal measurement	Tool	Conduct related indexes	Problems with measuring
Electro dermal activity or skin conductivity (SC)	Electrodes	Indicator for stress, differentiate between conflict and no conflict situations	Affected by exterior factors, need reference measurement and calibration
Heart Rate (HR), Inert Beat Interval (IBI). Heart Rate Variable (HRV)	Electrocardiogram (ECG)	Fear and anger, intensive attention, low HVR indicate relaxation, high HVR indicate stress or frustration.	Recording ECG from limbs is less inconvenient but more vulnerable to artifacts
Blood pressure (BP)	Sphygmomanometer	Anger, stress, process data capacity and attachment with tasks	Prone to jamming related to changes in physiological characteristics
Blood Volume Pulse (BVP)	Plethysmograph	New and unexpected stimuli	Reduce mobility of human and distraction of emotion reactions
Brain activity	Electroencephalography (EEG)	Alpha (relax state) Beta (active, busy) Gamma (problem solving, fear)	require expertise and the use of special, expensive, equipment
Pupillary response	Eye tracker	Fatigue and workload	Reliance on non-transparent invasive sensors
Facial muscular Activity	Electromyogram (EMG)	Emotion state	invasive sensors

Several researchers in HCI field focused on detecting emotional states by using bio-signal tools to distinguish different patterns in physiological activity. However, the complications in implementing experiment rules, high budget and time limits are obstacles forbidding using those tools at large scale. Designing standards for domains like excitors for distinguishing different physiological patterns, physiological scales, with clear characteristics are based on emotional model to support HCI field. The bio-signal tools can expose the invisible cues of human, and there is no agreement regarding the physiological patterns.

3.3.1 The difficulties with inferring emotions from psychological behavior

Most of bio-signal instruments need physical contact with the user, so these instruments are becoming parasitical when they are implemented to human. These instruments use annoying materials for human to enhance signal readability like conductive gel, skin abrasion etc. In addition, there is difficulty related to latency in stimulus appearance and physiological signal reading. The user action is very fast, and it is a hard task for the researcher to determine the cause of the state change for user, because the physiological signal needs amount of time to react. The third difficulty are external variables that could affect the user as time of the day, temperature, atmosphere, and physiological activity. The last difficulty is mental states and physiological responses. How we can differentiate physiological responses in different mental states, because sometimes two different mental states have the same physical response.

3.4 Inferring emotions from facial expression

Human can express his feelings and emotions using verbal and nonverbal cues. Nonverbal cues have their own channels to transfer feelings and emotions such as text, audio, physiology and visual. One of the visual communications or transfer channels is body language that includes hand gestures, body postures, and facial expressions etc.

Facial expressions are created as result of contract of face muscles, the operation of face muscular relaxation and contraction deform the facial expression system. Each facial deformation have its feeling or emotion meaning. Recognizing facial expression depends on many factors like the classification of facial motion and facial feature deformation to abstract classes based on visual information (Fasel and Luetttin, 2002). Facial expressions are

generated from different factors such as verbal and nonverbal communications, mental state and physiology activity. The following figure explains these factors.

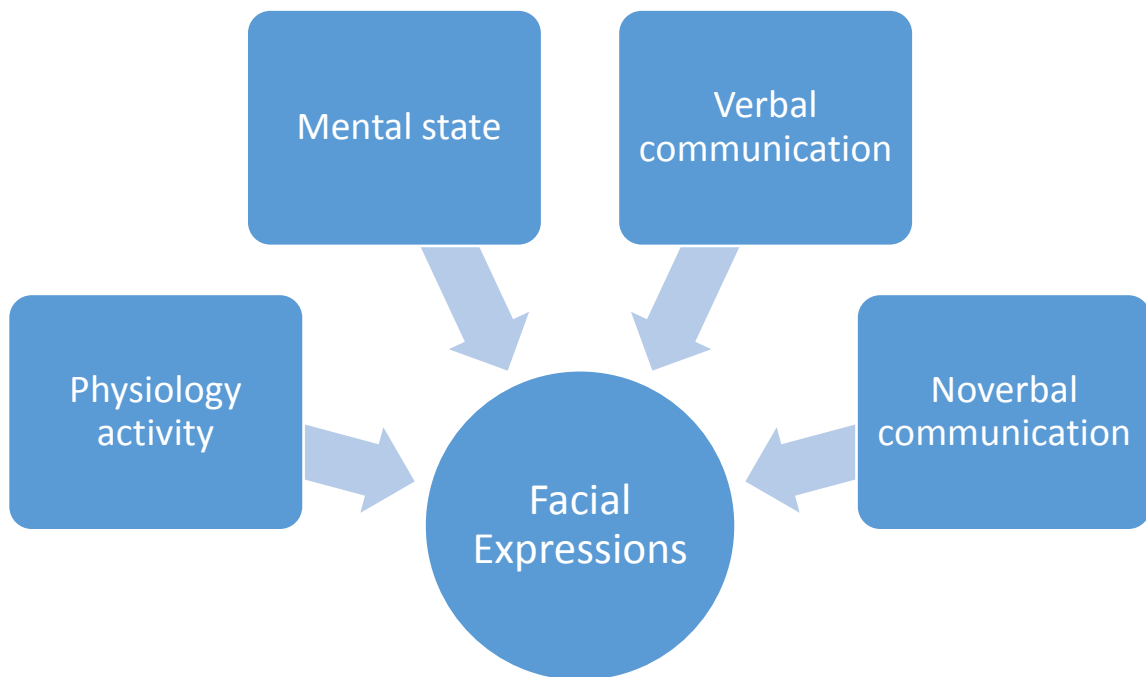


Figure (3-7): Sources of facial expression(Adopted from (Fasel and Luetin, 2002))

(Ekman and Friesen, 1975) mentioned in their book unmasking the face that face is not only a multi signal system, but also a multi message system. They explain multi signal as face having three types of facial signals:

- 1- Static facial signal includes permanent aspects of the face like shape, skin color, bone structure etc.
- 2- Slow facial signal includes changing of the facial look slowly over age. It may change face skin texture, skin color, muscles tone and appearing of permanent wrinkles.
- 3- Rapid facial signal includes changing in facial features for second or fraction of a second. In this case, the face muscles are moving and forming temporary wrinkles.

Besides that, face transmits messages about emotion, mood, age etc. Therefore, the face is also a multi message system (Ekman and Friesen, 1975).

3.4.1 Psychological approaches of facial expressions analysis

There are two approaches used by researchers in automatic analysis of facial expressions:

- 1- Facial effect (emotions)
- 2- Facial muscles action (action unit)

These two approaches are derived from the two psychological models that are used to analyze facial expressions. The psychological approaches are:

- 1- Judgment based approaches or “message judgment approaches”

The objective of this approach is to indicate the message behind the facial expression. The facial expression or mental status have its predefined class of emotions. Coders’ group consensus on emotions inferred from facial expression or mental status by computing the average of the responses of the users, this consensus possessed the absolute truth (Fasel and Luetin, 2002). A problem in judgment-based approach is that it may be affected by context of observation behavior of human face (Bettadapura, 2012).

- 2- Sign based approaches or “vehicle based approaches “

The basic idea behind vehicle-based approach is to characterize the facial muscles movements and temporary wrinkles that face create into visual classes, each movement is determined by its location and intensity. A complete system contains all possible forms of face (Fasel and Luetin, 2002). The following sections will explain coding systems that are used in the analysis of facial expressions.

3.4.2 Measurement coding systems for facial expressions

In the previous section, we talked about approaches used in psychology to infer emotion from facial expression (message and sign based approaches), the about the approaches in computer science that stem from psychology approaches (facial affect and facial muscles action). In this section, we will talk about the measurement system that is built on the concept of message based approach as Ekman's six basic emotions (anger, disgust, fear, happiness, sadness and surprise), Plutchick emotion wheel and Russell's Circumplex model (Valstar, 2008). These three coding systems introduced as a classifying method for complex mental states and characterized the message of facial expression as confused, concentrating or attentive.

We will discuss the measurement system built on sign based approaches as FACS that is commonly used in computer science and psychology, and MPEG-4 that is only used in computer science. The following paragraphs will explain the coding systems in details:

1- Ekman's six emotions approach

This coding system is one of the message-based approaches. Its main idea is that there are six basic emotions anger, disgust, fear, happiness; sadness and surprise have been developed in the same way for all humans. Moreover, our facial expressions are the stage presenting these emotions, and these demonstrations are created and identified independently of natural or cultural effects. The six basic emotions are related to the universal small group of facial expressions.

The famous scientist *Darwin* mentioned in 1872 that humans and animals have similar expressions in similar situations, which means that both cat and human show a particular expressions when they are afraid or feel pain. We should notice the difference in the way that expression was presented for both, while the emotion that caused the expression was the same. From this point, *Darwin* concluded that facial expressions are related to the

evolutionary of human on behalf of culture and heritage. Paul Ekman in his book *Emotions Revealed* (Ekman,2003) has studied different societies like New Guinea, the United States, Japan, and Brazil....etc. His objective was to develop ideas about emotions and facial expressions and to prove that facial expressions are unique among different cultures. For example, he studied culturally isolated New Guinea society, at the beginning he watched films and noted that he did not see anything not seen before, then he traveled to New Guinea and met tribesman, and showed them pictures from different societies displaying facial expressions emotions. The results of *Ekman* study suggested that tribesmen have the ability to identify the six basic emotions. Therefore, the facial expressions are unique across cultures while emotions are not culturally learned, but they are related to genetics.

The following are problems with *Ekman*'s six basic emotions:

- a- Human can display truly emotions using facial expressions when he or she feels the emotion, but sometimes he or she displays the same facial expressions with no emotion for some reasons like social impact. So how would we use this facial expression as an indicator to the felt emotions?
- b- The coding system is not able to recognize emotions outside the six basic emotion, because *Ekman* did not suggest that the six emotions are the only emotions, and he did not mention that facial expressions of these emotions are the only facial expressions.

Based on the previous problems, we observe that the coding system that belongs to message judgment approach cannot capture all possible facial expressions and felt emotions.

2- Pultchik's approach

Plutchik's emotion theory is composed of eight emotions: acceptance, anger, anticipation, disgust, fear, joy, sadness and surprise. There are the eight primary emotions; also, there are secondary emotions that can be found by crossing the primary eight emotions.

Pultchik in 1980 designed his colored emotion wheel in three-dimensional Circumplex model. The Circumplex model showed the relation between one emotion and the other emotion. This model can help us to trace emotions, secondary emotions can be found by crossing primary emotions. The following figures (3-8 and 3-9) explain the model that consists of emotion wheel and emotion cone of Pultchik, which he designed to explain his idea of coding system.



Figure (3-8): Emotion cone of Pultchik (Reprinted from (Wikiversity, 2015))

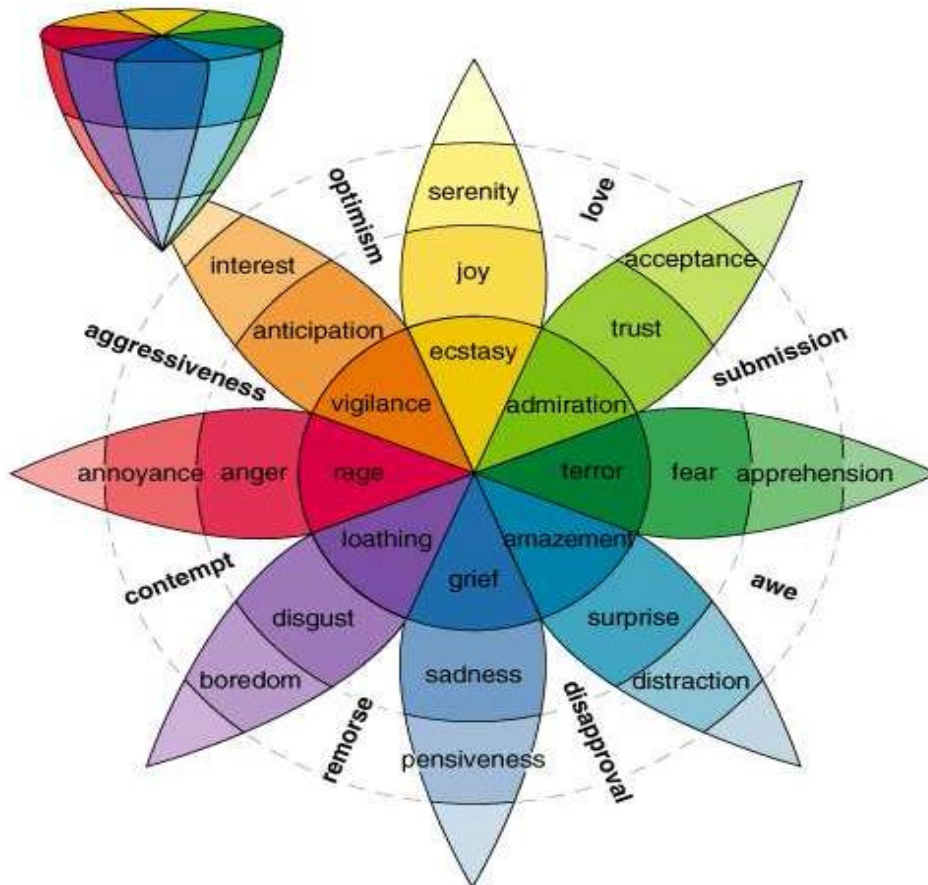


Figure (3-9): Emotion wheel of Pultchik (Reprinted from (Wikiversity, 2015))

The cone's vertical dimension describes the intensity of emotion, the intensity increases as we move towards the wheel and decreases as we move outward; the darker the shade the more intense.

The placement in the circle describes the primary emotion, when we move to center of the wheel the colors become extreme, and when we move outer, the colors become milder. For example, admiration is stronger than trust but acceptance is weaker.

There are eight sectors indicating the eight primary emotion dimensions; created by four pairs of opposites like: joy is the opposite of sadness, fear opposites of anger, anticipation is the opposites of surprise, and disgust is the opposite of trust (Wikiversity, 2015).

The secondary emotions can be formulated by crossing two primary emotions the following table (3-2) provides a comprehensive example:

Table (3-2): The primary emotions crossing (Adopted from (Wikiversity, 2015))

Primary emotion crossing	Secondary emotion produced
Anger + Anticipation	Aggressiveness
Anticipation + Joy	Optimism
Joy + Trust	Love
Trust + Fear	Submission
Surprise + Sadness	Disappointment
Sadness + Disgust	Remorse
Fear + Surprise	Alarm
Disgust + Anger	Contempt

The *Pultchick* theory is based on our inner state and the way we feel (Valstar, 2008). He suggested that emotions serve at least eight adaptive behaviors explained in table (3-3). These adaptive behaviors are biologically primitive and essential for human and animal survival and reproductive fitness.

Table (3-3): Adaptive behavior and Emotions (Adopted from (Wikiversity, 2015))

Biologically primitive	Emotions
Protection	Fear, Terror
Destruction	Anger, Rage
Incorporation	Acceptance
Rejection	Disgust
Reproduction	Joy, Pleasure
Reintegration	Sadness, Grief
Exploration	Curiosity, Play
Orientation	Surprise

Pultchik coding system is a message based approach and have the same problems of six basic emotions:

- A-** There is no guarantee that what we feel is shown by facial expressions.
- B-** Some non-communicative signals such as a brow flash used in greeting cannot be described by the system.
- C-** This coding system depends on the feeling.

3- Russell's approach

Many psychologist refused the six basic emotion theory of *Ekman*, because they think that affective states are related to each other and are not independent or discrete (Valstar, 2008). On the other hand, some of them begin to think in dimensional view of affective state and emotions.

One of the psychologists who was influenced by dimensional view of affective states is James Russell, He created two-dimensional space by putting all emotions in a circle around the center of crossing the two axis, the first axis is valence and the second is arousal. Valence ranges from sadness to happiness, while arousal ranges from sleepiness to excitement. Figure (3-10) explains the system.

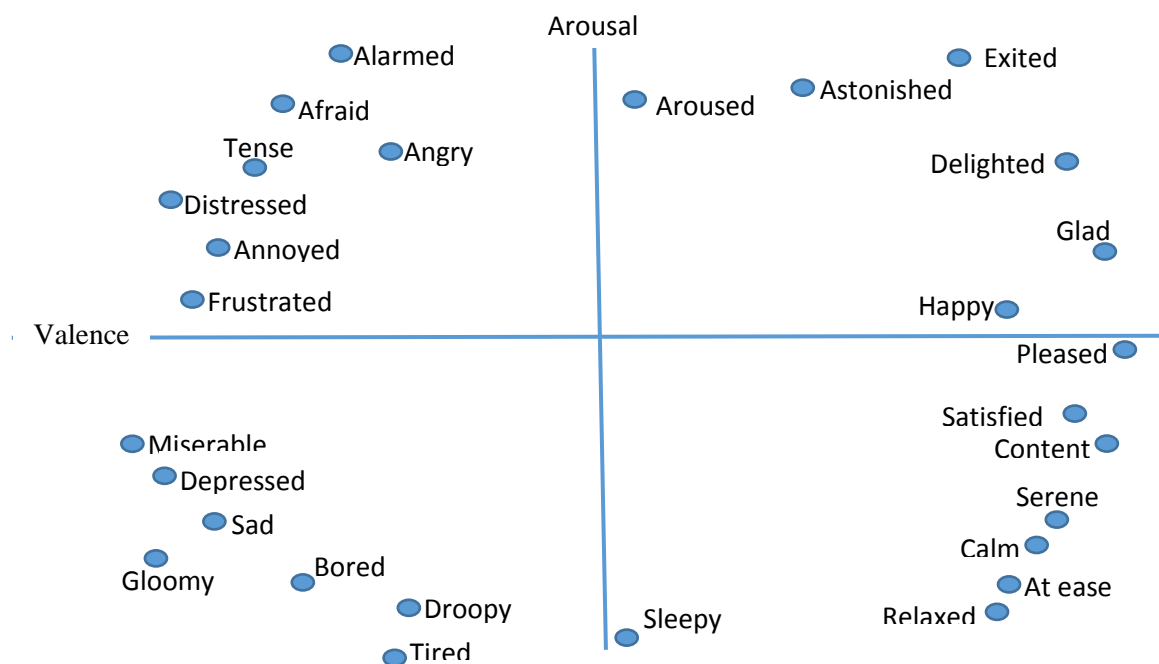


Figure (3-10): *Russell's* Circumplex model (Adopted from (Valstar, 2008))

The *Russell's* model is as follows:

- A- Real world experience suggests that *Russell's* dimensions are correlated, but based upon *Russell's* theory they are independent.

B- *Russell's* theory states that emotions are in a circle, but in reality, they are distributed in V-shape.

C- Negative affective state have a higher intensity (few pleasant things → unpleasant things) higher intensity amplifies valence (a very large steak is much more pleasant than small steak)

D- It is not obvious how facial expressions are mapped to space and vice versa.

4- Facial Action Coding System (FACS)

Ekman and Friesen developed FACS in 1977. Before FACS the researchers in facial action were depending upon the message judgment based approach that is entirely based on visual observation of the human face affected by context especially voice. In addition, the observations cannot scientifically exact, because the observers are not reliable or accurate, the observer may be influenced by context. However, the observations are not the same across cultures; different cultural groups have different interpretations (Ekman, 2003).

Since 1920s, researchers of facial expressions have strenuous efforts to develop a system for measuring facial expressions, but there were no agreement on reliable framework, until *Ekman* and *Friesen* developed FACS that became the reliable standard.

Facial action coding system is focusing on special parameters in facial behavior that is based on distinguishing different facial muscles movement in individuals or groups that causes changes in facial manner. The deformation of face that results from the changes in facial muscles (one or more) are called action units (AUs). FACS is composed of several action units; the system defines 32 atomic action units (AUs) and 34 action descriptors (ADs). The action units are 9 (AUs) in the upper face, 18 (AUs) in the lower face, and 5 cannot be classified as belonging to either the upper or the lower face. The following figures (3-11, 3-12, and 3-13) are showing the action units.



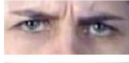






	AU1 Raised inner eyebrow		AU2 Raised outer eyebrow
	AU4 Eyebrows lowered and drawn together		AU5 Raised upper eyelid
	AU6 Raised cheek, compressed eyelids		AU7 Tightened eyelids
	AU43 Eyes closed		AU45 Blink
	AU46 Wink		

Figure (3-11): The upper face action units(Reprinted from (Branco,2006))





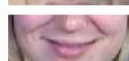
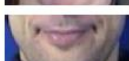



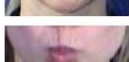




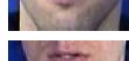



	AU8 Lips towards each other		AU10 Raised upper lip
	AU11 Deepened nasolabial furrow		AU12 Lip corners pulled up
	AU13 Lip corners pulled sharply up		AU14 Dimpler - mouth corners pulled inwards
	AU15 Lip corners depressed		AU16 Lower lip depressed
	AU17 Chin raised		AU18 Puckered lips
	AU20 Mouth stretched horizontally		AU22 Lip funneled and protruded
	AU23 Lips tightened		AU24 Lips pressed
	AU25 Lips parted		AU26 Jaw dropped
	AU27 Mouth stretched open		AU28 Lips sucked into the mouth

Figure (3-12): The lower face action units(Reprinted from (Branco,2006))



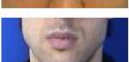
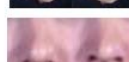
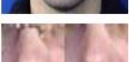
	AU9 Nose wrinkler		AU21 Neck tightened
	AU31 Jaw clenched		AU38 Nostril wings flared out (left is neutral, right active)
	AU39 Nostril wings compressed (left is neutral, right active)		

Figure (3-13): Actions Units belong to both the upper and the lower face (Reprinted from (Branco,2006))

The actions descriptors (ADs) are: 11 action descriptors for head position, 9 for eye position, and 14 for miscellaneous actions. The action unit (AU) is the smallest visually discernible facial movements, is characterized as atomic that means no (AU), and can be divided into

smaller component. Any facial expression can be described by a combination of AUs. An example for combination (genuine smile) is a combination of AU6+AU12.

The AUs have two types additive and non-additive. The additive AUs have their independent appearance for each, while the non-additive AUs modify the appearance of each other.

Each expression is composed of one or more additive and non-additive AUs. The following table (3-4) shows different examples of the emotion expressions and actions unit combinations.

Table (3-4): Emotion expressions and its combination (Adopted from (Wikipedia FACS ,2015)

Emotion expressions	AUs combinations
Happiness	6+12
Sadness	1+4+15
Surprise	1+2+5B+26
Fear	1+2+4+5+7+20+26
Anger	4+5+7+23
Disgust	9+15+16
Contempt	R12A+R14A

FACS provides guidelines and rules on for recognizing AUs' temporal parameter: onset (attack), apex (sustain), offset (relaxation), and how to score the intensity of facial action on five–point scale, figure (3-14) explains the guideline.

Facial action coding system has anatomical basis. Facial expression is formed from the movement of facial muscles, there are about fifteen muscles primarily used to create facial expression. The following table (3-5) displays the main muscles that are used in action units.

Table (3-5): Action units muscles, Adopted from (Valstar, 2008)

AU	Muscles	AU	Muscles
1	Frontalis (medial)	2	Frontalis (lateral)
4	Depressor supercillii, Corrugator, Procerus	5	Levator Palpebrae
6	Orbicularis oculi (pars orbitalis)	7	Orbicularis oculi (pars palpebralis)
8	Orbicularis oris	9	Levator Labii Superioris (alaequenasii)
10	Levator Labii Superioris (caput infraorbitalis)	11	Zygomatic minor
12	Zygomaticus major, Levator angulioris	13	Caninus, Levator anguli oris
14	Buccinator	15	Depressor anguli oris, Triangularis
16	Depressor labii inferioris 17 Mentalis	18	Incisivus Labii
20	Risorius	22	Orbicularis oris (outer part), Buccinator
23	Orbicularis oris (inner part)	24	Orbicularis oris (inner part)
25	Depressor labii inferioris, Mentalis, Orbiculairs oris	26	Temporalis, Masseter
27	Digastric, Temporalis, Masseter	28	Orbicularis oris
38	Nasalis (pars alaris)	39	Nasalis (pars transversa), Depressorsepti nasi
43	Orbicularis oculi	45	Levator Palpebrae, Orbicularis oculi
46	Orbicularis oculi		

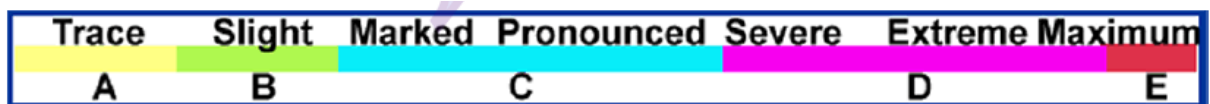
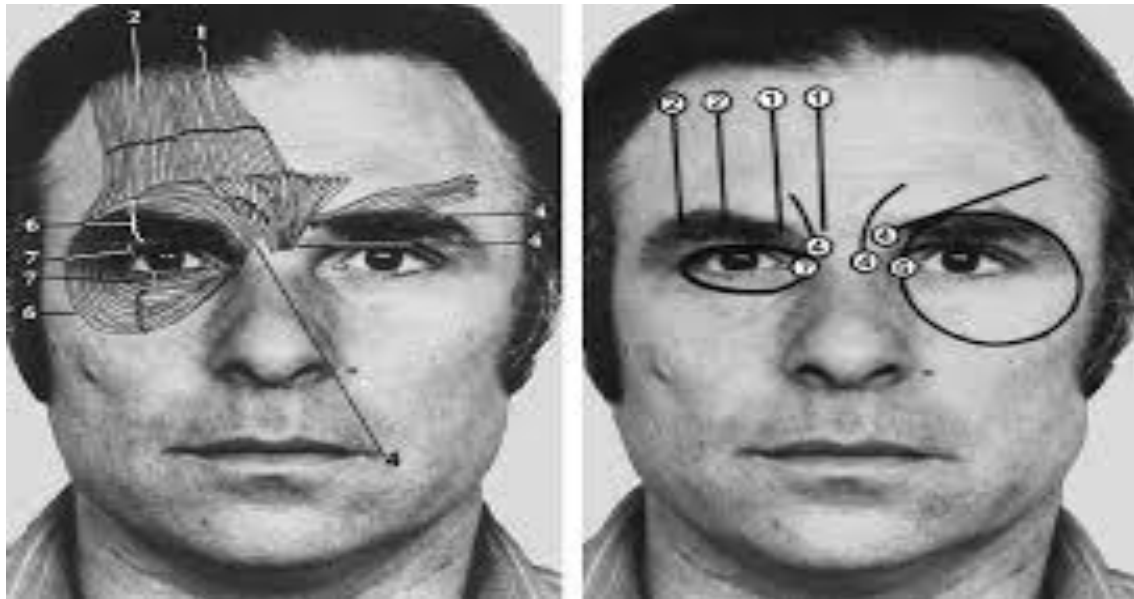


Figure (3-14): The five point scale intensity in FACS(Adopted from (Ekman & et al. ,2010))



Muscular anatomy

Muscular action

Figure (3-15): FACS has anatomical basis (Adopted from (Ekman & et al., 2010))

Ekman and colleges have launched a new release of FACS in 2002 with some changes like:

- A-** AU41 (drooped eyelid)+AU42 (slit eyes)+AU44 (squinted eyes) are become intensities degree of AU43 (eyes closed).
- B-** Intensity threshold for scoring has been removed.
- C-** A new guideline for intensity is added: a five-point scale for every AU.
- D-** Co-occurrence rules have been dropped.

FACS problems:

- A-** Sometimes the results are misleading related to lack of context information.
- B-** The results depends on the quality of image or video.

5- Facial Animation Parameters (FAPs) MPEG-4 standard

After FACS, the facial expression researchers faced the same issues that faced researcher in days that proceeds FACS. Many animation systems were developed with their own parameters and without standards to organize the development process; these systems seemed unusable across domains because researchers concentrate on facial movement that the parameter caused instead of concentrating on a combination of best parameters.

The Moving Pictures Experts Groups (MPEG) worked on a standardized facial control parameterization to address these issues. The group introduced the standard MPEG-4 with Facial Animation (FA) specifications version 1. MPEG became an international standard in 1999 (Bettadapura, 2012).

MPEG-4 is a standard for multimedia compression, having the ability of encoding each object separately. The face modeling in MPEG-4 is based on encoding faces and facial expressions. It is a 3D model defined by the face definition parameters (FDP) and the expressions on the face are described by facial expression parameters (FAP) (Valstar, 2008). The nature of face in MPEG-4 has specific properties like **a)** all face muscles are relaxed **b)** eyelids are tangent to the iris **c)** pupil is $1/3^{\text{rd}}$ the diameter of the iris and so on.

Other key features of neutral face model are defined like eye separation, iris diameter, etc. (Bettadapura, 2012). MPEG-4 standard defined 84 feature points (FPs) on the neutral face, and there are 68 low level FAPs. However, the FAPs have simple geometric definitions, like FAP-8 represents “Vertical displacement of midpoint between left corner and middle of top inner lip”, leaving many details in the definition of FDP and FAPs to designers. The following figure (3-16) shows the 84 FPs on the neutral face that MPEG-4 standard defined.

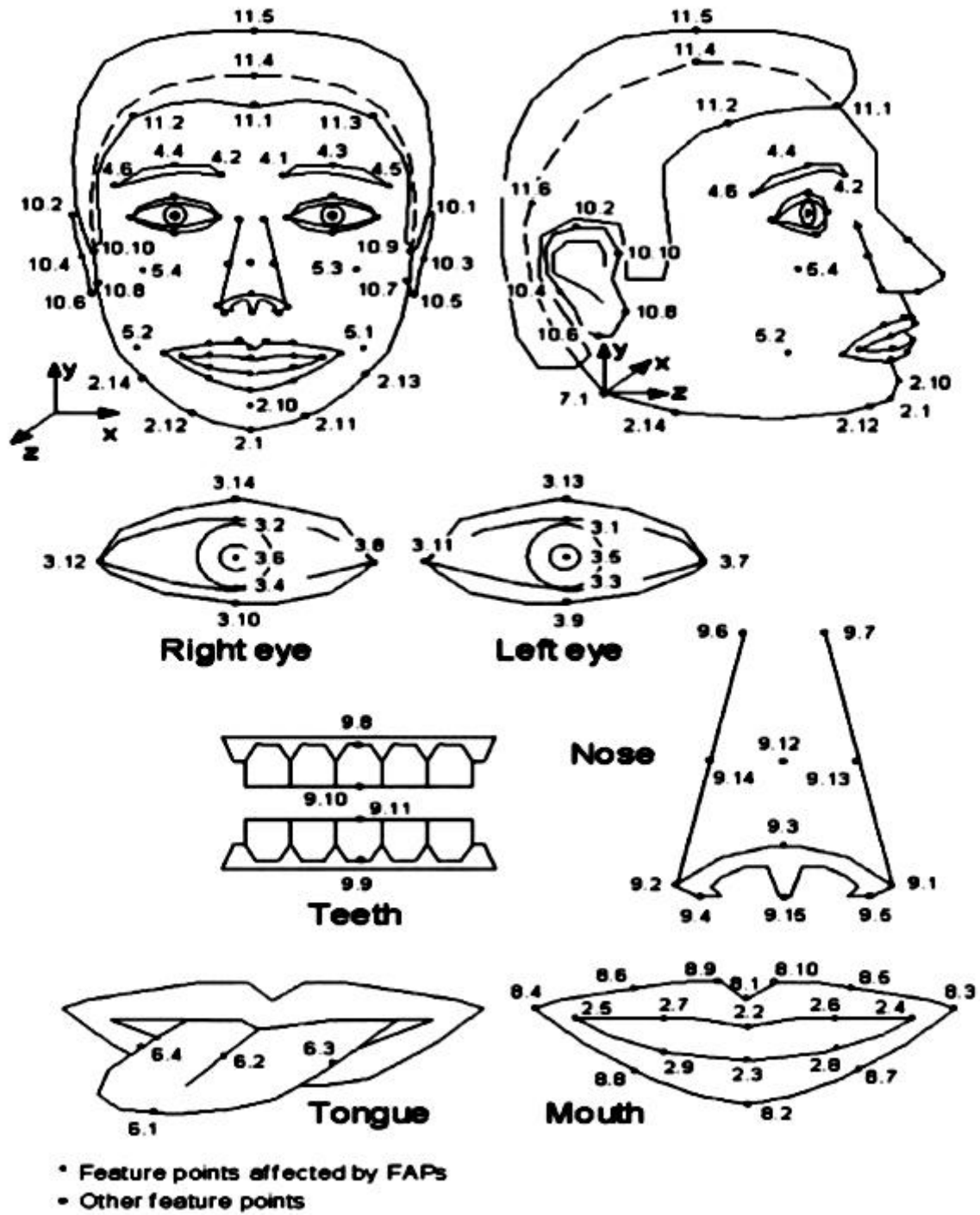


Figure (3-16): The 84 FPs of natural face in MPEG-4 standard(Reprinted from (Bettadapura, 2012))

FAPs consists of parameters that represent a complete set of facial actions along with head emotion, tongue, eye and mouth control, is based on muscles activations like AUs in FACS. Each FAP deforms a face model in its neutral state. The FAP value indicates the magnitude of the FAP, which in turn indicates the magnitude of the deformation that caused the neutral

model, such as small smile and big smile. The following table (3-6) displays some examples of FAPs and their descriptions.

Table (3-6): Some examples of FAPs and their descriptions

FAP No.	FAP Name	FAP Description
3	open_jaw	Vertical jaw displacement
4	lower_t_midlip	Vertical top middle inner lip displacement
5	raise_b_midlip	Vertical bottom middle inner lip displacement
6	stretch_l_cornerlip	Horizontal displacement of left inner lip corner
7	stretch_r_cornerlip	Horizontal displacement of right inner lip corner

MPEG-4 standard defines normalization of the FAP values, this normalization is done using Facial Animations, and the FAPUs are defined as a fraction of the distance between key facial features, where the FAP values are expressed in terms of these FAPUs. These specifications enable the FAP to describe the facial movements, and to be adapted to any model of various sizes and shapes. The following figure (3-17) shows neutral face with FAPU.

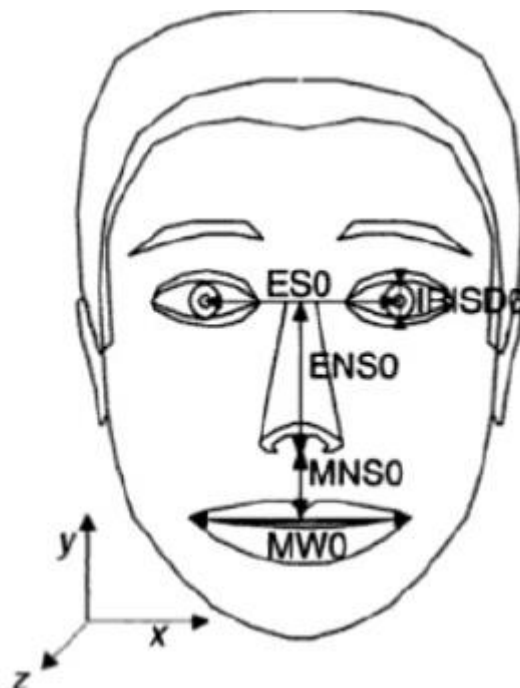


Figure (3-17): The FAPUs in neutral face FAPUs are: ESO (Eye Separation), IRISD0 (Iris Diameter), ENS0 (Eye-Nose Separation), MNS0 (Mouth-Nose Separation), MW0 (Mouth Width). Figure reprinted from (Bettadapura, 2012)

The 68 FAPs are grouped into FAP groups. Group1 contains two high level parameters: visemes and expressions. MPEG-4 defined six primary facial expressions: sadness, fear, disgust, joy, anger and surprise.

For example, the expression for (sadness) can be expressed using FAPs as follows:

close_l_eyelid (FAP 19), close_t_r_eyelid (FAP 20), close_b_l_eyelid (FAP 21), close_b_r_eyelid (FAP 22), raise_l_i_eyebrow (FAP 31), raise_r_i_eyebrow (FAP 32), raise_l_m_eyebrow (FAP 33), raise_r_m_eyebrow (FAP 34), raise_l_o_eyebrow (FAP 35), raise_r_o_eyebrow (FAP 36).

MPEG-4 FAPs are related to AUs of FACS. The following table (8) shows some example of AUs and their mapping to FAPs.

Table (3-7): Examples of AUs and its mapping in FAPs

Action Units (FACS AUs)	Facial Action Parameters (MPEG-4 FAPs)
AU1(Inner Brow Raise)	raise_l_i_eyebrow + raise_r_i_eyebrow
AU2(Outer Brow Raise)	raise_l_o_eyebrow + raise_r_o_eyebrow
AU9(Nose Wrinkle)	raise_t_midlip + raise_nose + stretch_l_nose + stretch_r_nose
AU15(Lip Corner Depressor)	lower_l_cornerlip + lower_r_cornerlip

The problem with such coding system is that it is a complex encoding, without the ability to describe the facial actions that induce changes in facial texture rather than displacements of facial points.

3.5 Monitoring hand over face gestures

Relating to kinesics, every body movement or part of body movement has its meaning and its objective.

In 1969, *Ekman* and *Friesen* have developed a classification system identifying five types of movement, the hand gestures were the most important factor of how the emotions are expressed and interpreted by the others. In human interaction, the interpretation in variety situations is more accurate when people observe the face and the body. The understanding of communication will be more with 35% based on the face and body rather than the face only (Mahmoud and Robinson, 2011). Hand over gestures are not extra information; they confirm the effective cues communicated through facial expression and speech that provides additional information about the communication. Many studies suggest that there is an overlap between face and the hand conditions, with other areas involved besides the face area in the brain. New meaning is added to affective cue, and additional regions in the brain were seen to be active when observed hand gesture was performed with emotion.

In cases when face and body expression, do not give the same meaning, experiments showed that recognition of facial expression was biased towards the emotion expressed by the body languages (Mahmoud and Robinson, 2011).

Not all our thoughts are transported in our speech; the unprompted gestures that we do when we talk transport our thoughts. Gestures are playing a role in reflecting and shaping our thoughts. There are many examples that clarify the relation between our hand gestures and our thoughts, like teacher and student example: The teacher uses his gestures, the students profit from his instructions that are included in his gestures. In addition, the teacher who uses gestures while explaining a concept is more successful in getting across the students ideas. Moreover, the student who uses gestures while working through new ideas tends to remember the idea longer than the student who does not use his hands. In general, using the

gestures during the instructions encourages students to produce gestures leading to learning. The Definitive Book of Body Language for *Pease and Pease* review meanings for different hand over gestures, and suggests different positions and actions of the hand occluding the face that can imply different affective states. The following figure (3-18) displays some examples of hand over face gestures adopted from(Pease and Pease,2004).

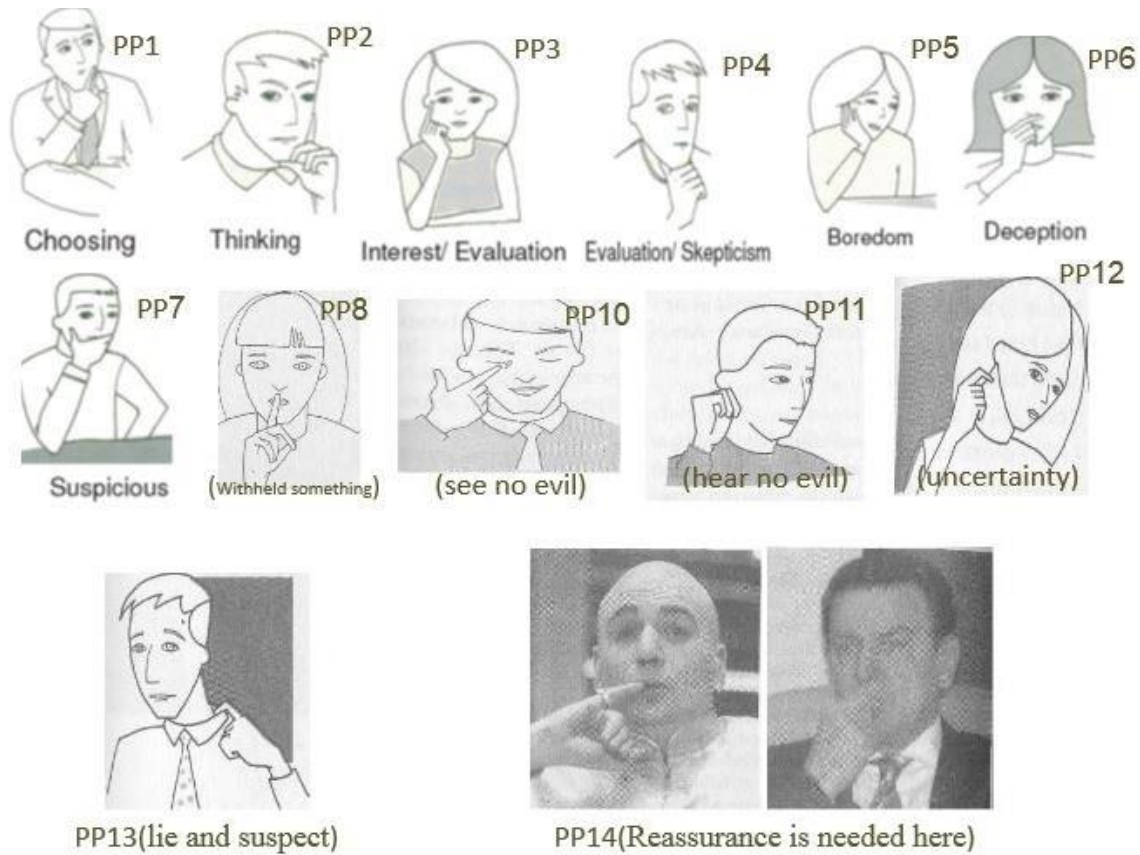


Figure (3-18): some examples of hand over face gestures(Adopted from (Pease and Pease, 2004))

In the PhD Thesis (Mahmoud and Robinson,2011), studied the hand over gestures, they designed an experiment by building Cam3D which is a 3D multi-modal corpus of natural complex mental states. The corpus consists of labeled videos of spontaneous facial expressions and hand gestures for 12 participants, from different ethnic backgrounds and various study and work fields. The task was to extract natural expressions, and the results were extracted by studying the videos in Cam3D. They analyzed hand over face gestures

and their possible meanings in unprompted expressions, they noted that hand over face gestures occur frequently, and can serve as affective cues. Figure (3-19) shows some examples of segments in experiment.



Figure (3-19): Some segments in Mahmoud and Robinson experiment(Reprinted from (Mahmoud and Robinson, 2011))

The results of *Mahmoud and Robinson* experiment are as follows:

- 1- Hand over face gestures appear in 21% of video segments (94 segments) with 16% in computer-based session and 25% dyadic interaction session.
- 2- The participants varied how much they gestured. Some of them a lot and others a few.
- 3- From 94 hand over face gestures segments, hand covered upper region 13% of segment and lower face covered 89% of them, with some videos having hand overlapping both upper and lower face regions.
- 4- These results suggest that the hand over face gestures are very common, and that hand cover lower face regions more than upper.

Mahmoud and Robinson encoded hand over face gestures in three cues: hand shape, hand action and facial region occluded by the hand. The following figure (3-20) shows the encoding of hand-over face shape and action in different mental states.

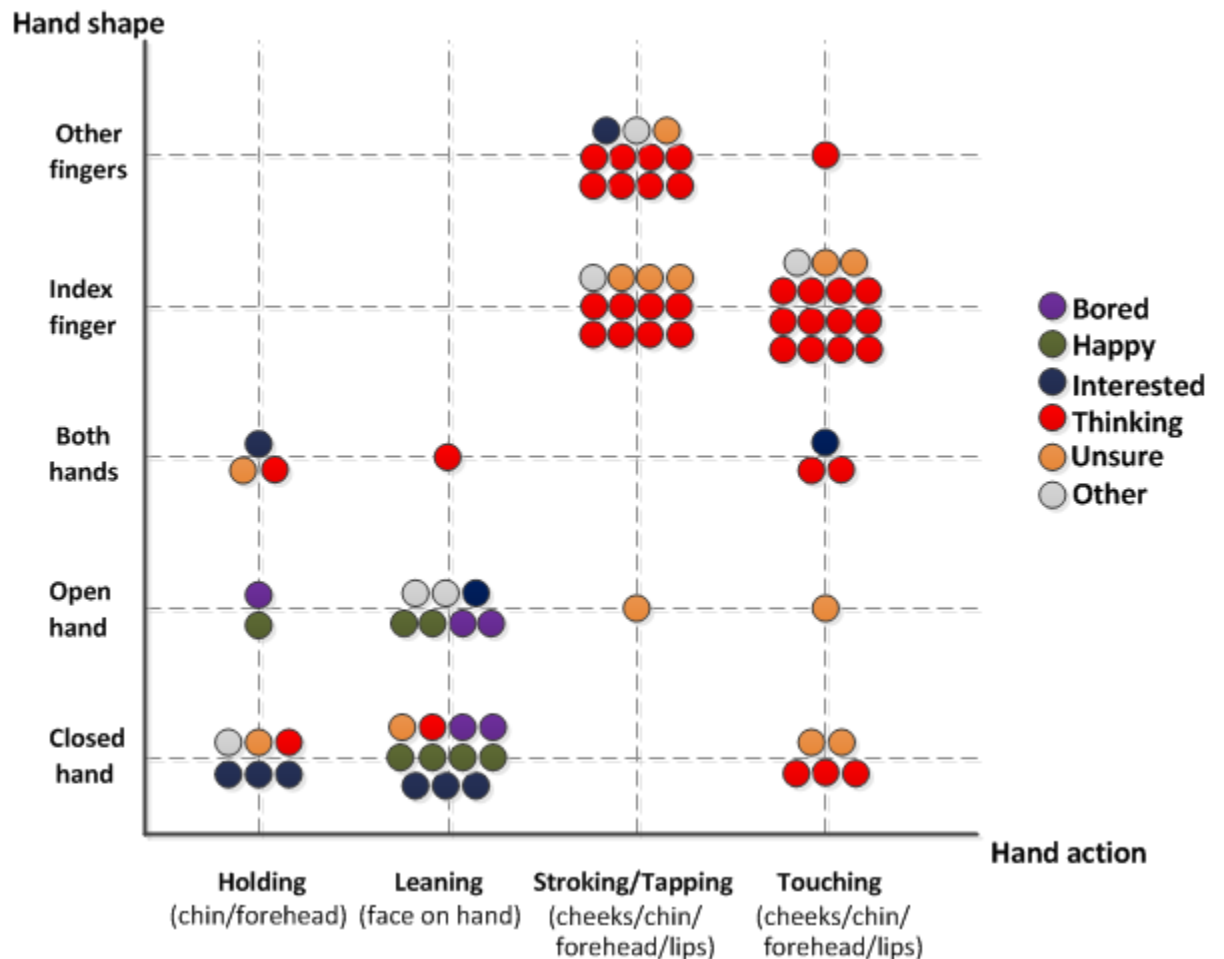


Figure (3-20): Encoding of hand over face shape and action in different mental states. Note the significance of the index finger actions in cognitive mental states (Reprinted from (Mahmoud and Robinson, 2011))

3.6 Discussion

In this chapter, we study different methods in monitoring and inferring emotions from different resources. We see that we can infer emotion by traditional ways from psychological behavior through blood pressure, eyelid, etc. We have also talked about the problems facing these methods. We have talked about how to measure emotions using facial expressions and the different coding systems that we use to measure these

facial expressions. We have also seen the suitable coding system FACS that can be used in psychology and in computer science, and the closet one to this model is MPEG or Facial Animation Parameter used only in computer science. We have seen that we can also measure emotions from hand over face gestures using the analysis method used by *Mahmoud and Robinson*. This chapter is the key tool that can be used to build a new method to analyze emotions of any user and to measure the user experience or the usability of any software.

4 Chapter Four : Inferring User Experience using Digitally Transformed /Converted Emotions (MUDE Model) “Literature Review”

4.1 Introduction

When humans interact with environment, they try to do their best to adapt with their perimeter. The adaptation enables humans to succeed in dealing with difficult issues that face them. Humans develop different tools and techniques to control their interaction with the perimeter, and make their interaction easier (<http://www.usabilitybok.org/what-is-usability/history-of-usability>, 30/5/2015).

Tools turned to be sophisticated and very accurate in producing the style of human lives. In addition, the expediency of design grows significantly; the industrial progression lead to a scientific field called ergonomics (Faulkner, 2006).

User experience and usability details is discussed in this chapter as history, development cycle, definitions, factors, metrics and measurements.

4.2 A Brief History of Usability and User Experience

The history of usability started from ancient times (1st century BC) when *Marcus Vitruvius Pollio* suggested three principles of design. The three principals were (1) *Firmitas* refers to the strength and the durability of design (2) *Utilitas* refers to the usefulness and suitability of users' needs and (3) *Venustas* that means the beauty of the design. These three principles inspired *Leonardo da Vinci* to draw *Vitruvian Man* figure (4-21), who drew measuring and calculating of the proportion of human body. *Vitruvius* is considered the first researcher of ergonomics and usability (Soegaard, 2012).

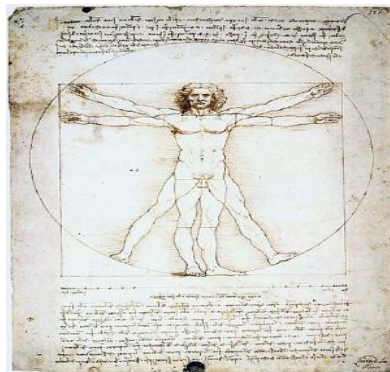


Figure (4-21): *Leonardo Da Vinci* drew the Measuring and calculating the proportion of the human body (Reprinted from (Soegaard, 2012))

In the end of 1980s, the term “usability engineering” appeared by *Joun Whiteside* and *Joun Bannett* in the form of studies and papers focusing on setting, prototyping an iterative evaluation. At the same time *Joe dumas* attributed work of *Joun Whiteside* and *Joun Bannett*, and this period is considered as the birth of usability as profession. In 1989, Technology Acceptance Model (TAM) was developed including a questionnaire for measuring usefulness and usability published by *Fred Davis*.

The usability in 1990s reached some level of maturity. In 1990, *Shackle* published a paper “Human factors and Usability” in which he defined usability as a function of efficiency, effectiveness and satisfaction (ISO 9241pt 11-standard). In the same year, *Jacob Nielson* and *Rolf Molich* published “Heuristic Evaluation of User Interfaces” that described the

discount of usability method. In the next year, a group of HCI interested established the Usability Professionals Association (UPA). They started the usability special interest group in the society of technical communications. In 1995, UPA held the first annual meeting in Portland Maine. In the same year, *Jacob Nielsen* published the “first bi-weekly column on usability” on useit.com. By the end of 1990s, specifically in 1998, usability became a standard embodied in ISO 9241 pt. 11. (<https://measuringu.com/usability-history/>, 30/5/2015).

In 2000s, the idiom “Remote Usability Testing” appeared. Therefore, the first publication appeared in 2002 (An Empirical Comparison of Lab and Remote Usability Testing of Web Sites) which is about remote usability testing by *Tom Tullis et al was*. In 2012, the UPA changed its name to User Experience Professionals Association (UxPA).

4.3 Usability

In the previous section (4.1), we explored important points in usability history. In this section, we will try to define usability depending on three point of views: International Standards Organization (ISO) point of view, Usability Professionals Association (UPA) or User experience Professionals Association (UxPA) point view, and the specialist writers point view.

ISO defined usability in ISO (9241-11) “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (Tullis and Albert, 2008). In 1999, ISO (9241-11) has been revised to ISO (9241-210).

The extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (Bevan, 2009).

UPA or UxPA defined usability as “an approach to produce development to reduce costs and create product and tools that meet the user needs”. Some writers like *Steve Krug* in his book (*Don’t Make Me Think*, 2006) defined usability as “making sure that something works well: that a person of average (or even below average) ability and experience, can use a thing—whether it’s website, a fighter jet, or revolving door, for its intended purpose without getting hopelessly frustrated”. Other writers like *Joseph Dumas* and *Janice Redish* saw usability in their book (*A Practical guide to usability testing*, 1999) as “people who use a product, can do so quickly and easily to accomplish their own task”.

It is important to realize that usability is not a single, one-dimensional property of a user interface. Usability has multiple components and is traditionally associated with five usability attributes: learnability, efficiency, memorability, errors, and satisfaction.

The previous definitions that came from different point views (International Standards Organization (ISO) point of view, Usability Professionals Association (UPA) or User experience Professionals Association (UxPA) point view, and the specialist writers point view) have common themes:

- 1- Usability is focusing on users
- 2- User is doing something with a product, software, application, etc.
- 3- Users use product to be productive
- 4- Users are busy trying to accomplish tasks
- 5- Users decide when a product is easy to use

4.4 User Experience

We will define user experience from three point views: ISO, UPA or UxPA and specialist writers. The ISO (9241-210) defined user experience as “A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service” (Bevan, 2009). The UxPA group defined the user experience as “Every aspect of the user's interaction with a product, service, or company that make up the user's perceptions of the whole. User experience design as a discipline is concerned with all the elements that together make up that interface, including layout, visual design, text, brand, sound, and interaction. UE works to coordinate these elements to allow for the best possible interaction by users” (UXPA ,2014).

Some writers who defined user experience like Marc Hassenzahl in his article (User Experience and Experience Design) as “User experience is not about good industrial design, multi-touch, or fancy interfaces. It is about transcending the material. It is about creating an experience through a device”(Hassenzahl,2013).

From the previous different definitions of user experience, we can conclude common themes:

- 1- A user is involved.
- 2- User is interacting with product, system, or really anything with an interface.
- 3- The users' experience is of interest, and observable or measurable.

4.5 The similarities and differences between Usability and User Experience

Many people think that usability and user experience have the same meaning, this is wrong, the two terms usability and user experience are not identical. Each term has its own distinguished meaning, components, and aim.

In the following subsections, we will observe the differences and similarities between usability and user experience. In addition, we will investigate the relationship between these two terms. Moreover, we will use some criteria to compare two terms as follows:

4.5.1 Definitions

The two terms have been defined in ISO 9241-210 (ISO 9241-210 ,2010) When we carefully read the two definitions, we note that usability is concerned with efficiency, effectiveness and satisfaction, while the user experience is concerned with users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use. The usability term is used to refer to pragmatic and non-emotional facets in user experience like objective performance measures, subjective opinion measures and qualitative data about usability problems. While user experience term is used to refer to internal feelings of the user including the effects of usability, usefulness and emotional impact (Hartson and Pyla, 2012).

User experience is “a consequence of brand image, presentation, functionality, system performance, interactive behavior and assistive capabilities of the interactive system, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use” (<https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en>) (2010). In addition, “When usability interpreted from the perspective of the users' personal goals, can include the kind of perceptual and emotional aspects typically associated with user experience” (ISO 9241-210 ,2010) .

Some experts defined the two terms as metaphor to clear the contrast between the two terms. They compared them to science (usability) vs. arts (user experience) and freeway (usability) vs. a twisting mountain road (user experience). This metaphorical representation is trying to describe usability as “something that is usable as functional, simple and requires less mental

effort to use. Thus, a freeway is usable since it has no oncoming traffic, enables you to get from point A to point B in a fast manner and has consistent signage, hence requiring little learnability”. In contrast, user experience is “a freeway is highly usable but it is boring when assessed. It is something that focuses on user experience depicted as highly emotional. Thus, a twisting mountain road is less usable but, because of its scenery, the smell of nature and the excitement of the climb, it conveys a pleasant user experience”.

4.5.2 Components and factors that influence

According to usability consultant *Jakob Nielsen* and computer science professor *Ben Shneiderman*, Usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process.

Usability is defined by 5 quality components. Next figure explain these components:



Figure (4-22): Usability 5 Quality components (Hartson and Pyla,2012)

While the user experience according to *Rex Hartson* and *Pradha Pyla* who wrote the book (*The UX Book: Process and Guidelines for Ensuring a Quality User Experience*), they mentioned in page (20) that usability and usefulness are components of user experience (Hartson and Pyla,2012).

Usability consultant *Jakob Nielsen* and computer science professor *Ben Shneiderman* noted that usefulness = usability+utility, where utility means whether it provides the features the user need. *Frank Guo* published an article on April 24, 2012 (Guo, 2012); in this article, he described a conceptual framework that four distinct elements of user experience. The four elements are:

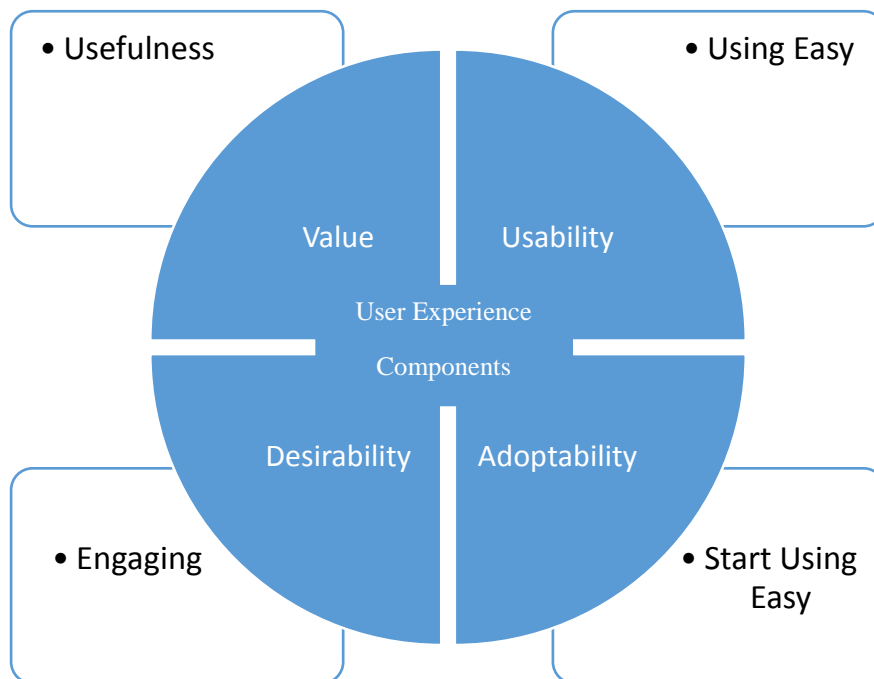
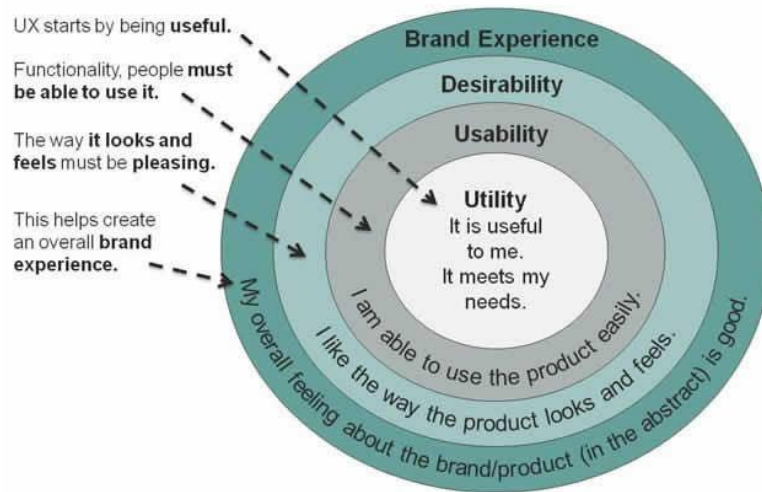


Figure (4-23): User Experience Components (Adopted from (Mifsud, 2011))

In July 11, 2011, *Justin Mifsud* published an article (Mifsud, 2011) he mentioned that user experience includes aspects such as:

1. utility
2. usability
3. desirability

4. brand experience



Source: User Experience 2008, nnGroup Conference Amsterdam
Retrieved from: <http://neospot.se/usability-vs-user-experience/>

Figure (4-24): The relationship component of usability and user experience(Reprinted from (Mifsud, 2011))

In June 21, 2004, *Peter Morville* has developed his imagination regarding user experience components or facets of user experience in an article, he called this imagination Honeycomb (Morville, 2004) where the suggested components are:

1. Useful: the application should be realize the target user needs
2. Usable: the application should be effortless
3. Desirable: the application should be contains all necessary design components like (identity, brand etc.), and it should arouse emotions and admiration
4. Findable: the application data content should be navigable and locatable (on/off) site
5. Accessible: the application design should consider people with disabilities (should be accessible for them)
6. Credible: the application data should be trusted and reliable

The following figure (4-24) is the Honeycomb:



Figure (4-25): Peter Morville Honeycomb, Adopted from (Morville, 2004)

According to the previous figure, we can conclude the components of user experience are as follows:

- 1- Utility
 - 2- Usability
 - 3- Desirability
 - 4- Adoptability
 - 5- User Experience
- Usefulness

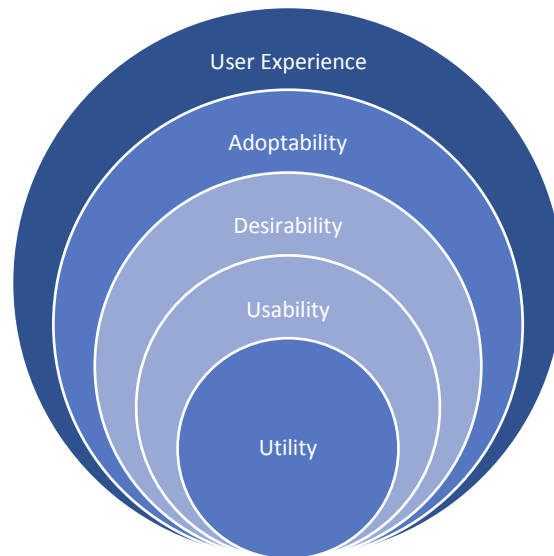


Figure (4-26): The relationship between usability and user experience(Adopted from (Merville, 2004))

4.5.3 Objectives

In general, the aim of usability is to make the application or software easy to use. In other words, it is related to the ease with which users can achieve their goals while interacting with application or software. On the other hand, user experience aim is to make the user happy before, during and after using the application or software. User experience is concerned with the way users perceive their interaction with application or software.

4.5.4 Requirements

Usability and user experience are different in the required resources. The usability needs employees who influenced the application or software design while user experience needs as a collective effort of employees from different departments like engineering, maketing, graphical, industrial design and interface design.

4.5.5 Influence

Usability concentrates on giving customers what they want, and providing checklist of features, but the user experience go beyond that. It enhances the relationship between the user and application or software despite needing more effort to do well.

4.5.6 Interface

The usability interface has its specific its own characteristics as intuitive, simple and learnable. However, when going to user experience, the interface is pleasing the user, so the user experience professionals hand over their designs to usability professionals, so that they can validate them.

4.5.7 Measurements

When looking deeply at usability and user experience definitions, we note that both can be measured during or after use of product, system or service (Bevan, 2009). Furthermore, when investigating the definitions of ISO (9241-210) for both usability and user experience, we see that the concept of persons' "perceptions and response" in user experience definition, is like the concept of satisfaction in usability.

Furthermore, we notice that definitions of both usability and user experience ISO (9241-210) are not concerned with time. Moreover, the definition of user experience do not deal with the way user experience improve, from expectation through actual interaction to total experience, that contain the reflection on the experience (Bevan, 2009). In addition, ISO 9241-11 definition of usability has nothing to do with learnability (where

usability changes over time). Therefore, there is no fundamental difference between measures of usability and measures of user experience at a particular point in time. The difference is between task performance and pleasure. Therefore, usability is the ability of user to carry out a task successfully, whereas user experience takes broader view concerning user's entire interaction with the thing as thoughts, feeling and perceptions resulting from interaction. Hence, when we discuss measuring usability we are concerned with the entire user experience (Tullis and Albert, 2008).

4.5.8 Usability and User Experience Metrics

The metrics that describe the way of measuring specific phenomena or thing. For example, when we say something is longer, taller or faster, we measure or quantify some attributes such as distance, height or speed (Tullis and Albert, 2008). In the process of needs measurement, the way of measurement must be agreed upon, consistent and reliable on. Each measurement is based on standard definitions, and is defined by a society as a whole. Metrics entered all areas of humans' lives, humans' uses metrics on daily basis such as time, distance, weight, height, speed, temperature and volume.

All industry activities and cultural activities have their own set of metrics. The auto industry is interested in the horsepower of a car, its gas mileage and the cost of materials. In computer industry, we are interested in processor speed, memory size and power requirements (Tullis and Albert, 2008). Usability and user experience field have a set of specific metrics as other fields in our lives. Task success, user satisfaction and errors, among others are the metrics of user experience (Tullis and Albert, 2008).

In ISO (9241-210) definition of user experience, focus on the phrase “usability criteria that can be used to assess aspects of user experience”. So, we can infer from previous sentence that metrics used for usability (learnability, satisfaction, errors, efficiency and

memorability) can be used for user experience as metrics, and we need to remember that usability is one component of user experience. The user experience metrics are different from other metrics; they measure something about humans, their behavior and attitudes. On the other hand, user experience metrics is about personal experience of the human being using a product or system. User experience metric represents the interaction between the user and the product, it represent effectiveness (ability to complete the task), efficiency (the amount of effort required to complete the task), and satisfaction (the degree of happiness with his or her experience while perform the task).

Table (4-8): Summary of the differences and similarities between usability and user experience

	Usability	User experience
Definitions	efficiency, effectiveness and satisfaction	emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments
Components	Learnability, Memorability, Errors, Satisfaction and Efficiency	Utility, Usability, Desirability, Adoptability and User Experience
Objectives	Make the application or software easy to use	Make the user happy before, during and after using the application or software.
Requirements	employees who influenced the application or software design	Engineering, marketing, graphical, industrial design and interface design.
Influence	giving customers what they want and providing checklist features	Enhance the relationship between the user and application or software despite it needs more effort to do well.
Interface	intuitive ,simple and learnable	pleasing to the user
Measures	ability of user to carry out a task successfully	user's entire interaction with the thing as thoughts, feeling and perceptions that result from interaction
Metrics	Learnability ,satisfaction, errors, efficiency and memorability	Task success ,user satisfaction and errors ,among others

4.6 Measuring User Experience using Digitally transformed/converted Emotions (MUDE model)

In this chapter, we propose a new model called Measuring User Experience Using Emotions (MUDE MODEL). This new model introduce new method in measuring user experience depending on emotions that transformed and converted from the facial expressions or gestures of human who interact with any application or program.

4.6.1 MUDE model components

We can summarized the components of MUDE as follow

1- User Experience Parameters “Usability Parameters “

As we see in section (4.5.2 Components and factors that influence) usability have its parameters Learnability, satisfaction, errors, efficiency and memorability. On the other hand user experience have its specific parameters utility, usability, desirability and adoptability .So , usability is a metrics of user experience and if we measure usability we can measure user experience .In other words , measuring Learnability ,satisfaction, errors, efficiency and memorability give us user experience.

2- The Emotions that Related to User Experience Parameters

According to section 3.4.2 Measurement coding systems for facial expression we discuss different types of approaches in emotions and measurement systems of transformed /converted emotions. One of these approaches is Pultchik’s approach .In Pultchik’s wheel the emotions have classified in primary emotions and secondary emotions (referred to figure (3-9) page 33).Depending on Pultchik’s wheel we can map each user experience parameter with its expected or related emotions based on its meaning as follow :

Table (4-9) : MUDE Model Mapping of User experience parameters

User Experience Parameters	Meaning of It Parameter	Related Primary Emotions
Satisfaction	How pleasant to use software	Joy
Learnability	How easy is it for users to accomplish basic tasks the first time they encounter the design?	Joy
Efficiency	Once users have learned the design, how quickly can they perform tasks	Joy
Memorability	When users return to the design after a period of not using it, how easily can they reestablish proficiency?	Joy
Errors	Errors occurrence	Anger, ,Surprise, contempt ,disgust, fear ,sadness

3 -Measuring Systems that Inferring Emotions from Facial Expressions and Hand Over Face Gestures.

In chapter 3 section 3.4.2 Measuring coding systems for facial expressions and section 3.5 Monitoring hand over face gestures, we discuss measuring systems that infer emotions from facial expressions and hand over face gestures. We will use in MUDE model Action Units (AUs) of FACS, Facial Animation Parameters (FAPs) and gestures of Pease &

Pease. Referring to chapter 3, page 46, Figure (3-18) to understand the gestures of *Pease & Pease* like pp3 this means that *Pease & Pease* picture number 3. Integrating the three previous components together, we can have a MUDE model. The following table explains the mapping between the metrics, expected emotions, action unit, FAPs and *Pease & Pease*. We take the satisfaction and errors as example for mapping between components.

Table (4-10) A: MUDE Model Mapping of User experience parameters → relative emotion → FACS → FAPs → *Pease & Pease*

User Experience (usability) Parameters	Emotions (That related to UX)	Inferring Methods			Logs
		FACS	FAPs	Pease & Pease	
Satisfaction (How pleasant is it to use the software)	Joy	6+12	open jaw (F3), lower t midlip (F4), raise b midlip (F5), stretch l corner lip (F6), stretch r corner lip (F7), raise l corner lip (F12), raise r corner lip (F13), close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l m eyebrow (F33), raise r m eyebrow (F34), lift l cheek (F41), lift r cheek (F42), stretch l corner lip o (F53), stretch r corner lip o (F54)	PP3	Review the recording of log file and see if user have been learn the methods of filling forms in addition we will consider the post – questionnaire

Table (4-10) B : MUDE Model Mapping of User experience parameters →relative emotion→FACS→FAPs→Pease & Pease

User Experience (usability) Parameters	Emotions (That related to UX)	Inferring Methods			Logs
		FACS	FAPs	Pease & Pease	
Errors (Errors occurrence)	Sadness	1+4+15	close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l i eyebrow (F31), raise r i eyebrow (F32), raise l m eyebrow (F33), raise r m eyebrow (F34), raise l o eyebrow (F35), raise r o eyebrow (F36)		
	Anger	4+5+7+2 3	lower t midlip (F4), raise b midlip (F5), push b lip (F16), depress chin (F18), close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l i eyebrow (F31), raise r i eyebrow (F32), raise l m eyebrow (F33), raise r m eyebrow (F34), raise l o eyebrow (F35), raise r o eyebrow (F36), squeeze l eyebrow (F37), squeeze r eyebrow (F38)		
	Surprise	1+2+5+2 6	open jaw (F3), raise b midlip (F5), stretch l corner lip (F6), stretch r corner lip (F7), raise b lip lm (F10), raise b lip rm (F11), close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l i eyebrow (F31), raise r i eyebrow (F32), raise l m eyebrow (F33), raise r m eyebrow (F34), raise l o eyebrow (F35), raise r o eyebrow (F36), squeeze l eyebrow (F37), squeeze r eyebrow (F38), stretch l corner lip o (F53),		

Table (4-10) C : MUDE Model Mapping of User experience parameters →relative emotion→FACS→FAPs→Pease & Pease

User Experience (usability) Parameters	Emotions (That related to UX)	Inferring Methods			Logs
		FACS	FAPs	Pease & Pease	
Errors (Errors occurrence)	Contempt (Disgust +Anger)	(9+15+16)) (4+5+7+2 3)	(open jaw (F3), lower t midlip (F4), raise b midlip (F5), lower t lip lm (F8), lower t lip rm (F9), raise b lip lm (F10), raise b lip rm (F11), close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l m eyebrow (F33), raise r m eyebrow (F34), lower t lip lm o (F55), lower t lip rm o (F56), raise b lip lm o (F57), raise b lip rm o (F58), raise l corner lip o (F59), raise r corner lip o (F60))+ (lower t midlip (F4), raise b midlip (F5), push b lip (F16), depress chin (F18), close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l i eyebrow (F31), raise r i eyebrow (F32), raise l m eyebrow (F33), raise r m eyebrow (F34), raise l o eyebrow (F35),raise r o eyebrow (F36), squeeze l eyebrow (F37), squeeze r eyebrow (F38))		

Table (4-10) D : MUDE Model Mapping of User experience parameters →relative emotion→FACS→FAPs→Pease & Pease

User Experience (usability) Parameters	Emotions (That related to UX)	Inferring Methods			Logs
		FACS	FAPs	Pease & Pease	
Errors (Errors occurrence)	Fear	1+2+4+5+7+20+26	<p>open-jaw (F3), lower-t-midlip (F4), raise-b-midlip (F5), lower-t-lip-lm (F8),</p> <p>lower-t-lip-rm (F9), raise-b-lip-lm (F10), raise-b-lip-rm (F11), close-t-l-eyelid (F19), close-t-r-eyelid (F20), close-b-l-eyelid (F21), close-b-r-eyelid (F22),</p> <p>raise-l-i-eyebrow (F31), raise-r-i-eyebrow (F32), raise-l-m-eyebrow (F33),</p> <p>raise-r-m-eyebrow (F34), raise-l-o-eyebrow (F35), raise-r-o-eyebrow (F36),</p> <p>squeeze-l-eyebrow (F37), squeeze-r-eyebrow (F38)</p>		
	Disgust	9+15+16	<p>open jaw (F3), lower t midlip (F4), raise b midlip (F5), lower t lip lm (F8), lower t lip rm (F9),</p> <p>raise b lip lm (F10), raise b lip rm (F11), close t l eyelid (F19), close t r eyelid (F20),</p> <p>close b l eyelid (F21), close b r eyelid (F22), raise l m eyebrow (F33), raise r m eyebrow (F34),</p> <p>lower t lip lm o (F55), lower t lip rm o (F56), raise b lip lm o (F57), raise b lip rm o (F58),</p> <p>raise l corner lip o (F59), raise r corner lip o (F60)</p>		

For example: Satisfaction → one of related emotions is (Joy) → picture 6+picture 12 → open jaw (F3), lower t midlip (F4), raise b midlip (F5), stretch l cornerlip (F6), stretch r cornerlip (F7), raise l cornerlip (F12), raise r cornerlip (F13), close t l eyelid (F19), close t r eyelid (F20), close b l eyelid (F21), close b r eyelid (F22), raise l m eyebrow (F33), raise r m eyebrow (F34), lift l cheek (F41), lift r cheek (F42), stretch l cornerlip o (F53), stretch r cornerlip o (F54) → no Pease & Pease.

4.7 Discussions

We introduced a new model based on *Ekman* model, facial animation parameter model, and *Pease & Pease* gestures to formulate new model (MUDE). MUDE Model can be used to measure the User Experience of user using the expected emotions that user expressed before, during and after interaction with application or software. This new model makes the way of measuring so natural and not bothering users during the evaluation and measuring process. In addition, it provides us with the needed information without asking users. Furthermore, it is more accurate and truthful way, by which the researcher can determine the usability of application and user experience of user.

The method can be used to measure the impression of any human not only in HCI domain, but also in diverse domains like coffee shops, to take impression of customers about new drinks. We can also use the model in airports to take feedback from passengers about services that have been served to them.

I think that this model will have a wide range of uses in different domains.

5 Chapter Five: Measuring Usability and User Experience by experiment “SUS Questionnaire Meets Intel Interactive Gestures Camera “

5.1 Introduction

In the previous chapter, we discussed a new model (MUDE) that measures user experience including usability through digital emotions. MUDE model depends on models like *Ekman Model* (FACS), FAPs and *Pease and Pease*.

In this chapter, we will introduce an experiment showing different methods that measure user experience and usability. We use Intel interactive gestures creative camera, its software uses FAPs model to capture 70 user emotions. In addition, we design a paper-based questionnaire using SUS (System Usability Scale) questionnaire. SUS is a quick usability scale questionnaire; it contains 10 items with 5 options responses (*Likert scale*).

70 users will fill SUS questionnaire after the experiment, to investigate whether the attitudes of users emotions captured by camera about usability (indicating user experience) are consistent with the users attitudes in the questionnaire regarding usability that indicate user experience.

We expect from this experiment to introduce comparative study between two valid tools used to measuring usability (SUS and camera)and showing that camera can be substitute paper based SUS questionnaire which can be more sensitive and accurate .

System Usability Scale (SUS) questionnaire which called sometimes quickly and dirty usability scale have been developed by John Brooke before 26 years ago. It could be used to measure the usability of computer systems. It is a reliable and simple tool to evaluate usability and user experience (Brooke, 2013). Many researchers have been using the SUS in their experiments to get usability. For example, Perceived Usability Evaluation of Learning Management Systems: Empirical Evaluation of the System Usability Scale (Orfanou, Tselios, and Katsanos, 2015). In this paper, writers evaluate the perceived usability of Learning Management Systems (LMSs) (e-Class and Moodle) for 769 users. The results show the reliability and the validity of SUS for LMSs evaluations and robust for small samples size. Moreover, some more demographic information were extracted like gender, age, prior experience and etc.

A second example of experiments that used the SUS questionnaire is Exploring User Satisfaction for E-learning Systems Via Usage – Based Metrics and System Usability Scale Analysis (Harrati, Bouchrika, Tari, Ladjailia, 2016). In this experiment, researchers used the SUS questionnaire to measure user experience and usability of e-learning systems. Besides, SUS they used various metrics like: cursor distance, mouse clicks and task durations. They found that SUS is a tool which needs more automated analytical metrics that extracted from usage activities.

The third example is paper “An evaluation of DiaSuite toolset by Professional Developers Learning Cost and Usability” done by (Kabac, Volanschi, and Consel, 2015). This paper showing an experiment measuring the learning cost and usability for a design –driven, tool –based approach (DiaSuite). DiaSuite main concepts is revolving around Sense, Compute and Control (SCC). It is devoted to the design of applications that using sensors and actuators. The experiment involves four professional programmers. The final results show low learning cost for this tool and high usability index.

5.2 Description of the Experiment

The hypothesis of experiment is that the attitudes of users emotions captured by Intel interactive gesture camera that use FAPs model about usability, are consistent with the attitudes of users in a paper based on SUS questionnaire about usability. In addition, we aim to complete the analysis process by using SPSS 19 (Orfanou, Tselios, and Katsanos,2015). The goals that we expect to achieve are the following:

- 1- To implement the MUDE model in practical way using SUS questionnaire.
- 2- Using Intel interactive gesture camera to capture emotions (negative and positive) that indicate usability and prove it a reliable tool for this experiment.
- 3- Comparing the results and attitudes of the camera and questionnaire.
- 4- To evolve new way in measuring the usability and user experience
- 5- To collect data (emotions) naturally in real cases and situations with target user .

5.2.2 Methods

5.2.2.1 Participants

The number of participants is 70 participants (44 males and 26 females) with different ages ranging from 19 to 42.

The academic background of participants:56 B.A (16 Media and Television, 7 Computer Science, 2 IT, 1 MIS, 2 Mathematics,1 Physics and 1 political science), and 14 M.A(6 Computer Science , 1 Public Health and 7 MBA/ Entrepreneurial). The following table summarizes the personal description of participants and showing their computer and internet skills. For further information and demographic data please refer to appendix 12 page 125 that contain summary table of personal data of participants which describe their computer and internet skills. Also the reader can refer to appendix 13 to see figures showing demographic data of participants in page 126.

5.2.2.2 Experiment Environment

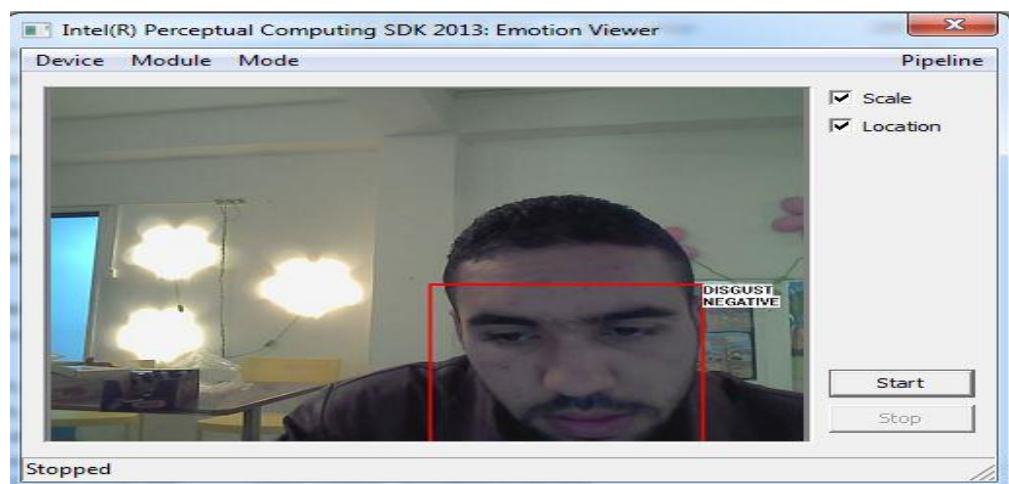


Figure (5-27): The Unconstraint Conditions of experiment

The experiment is done in unconstraint environment. The user followed different scenarios while using Website of Al-Quds University. Intel creative gesture camera recorded the facial expressions and gestures of the upper body of the participants using a recorder program that records every single move of mouse on screen and any sound of participant. After the experiment, the participants will be asked to fill the SUS questionnaire.

5.2.2.3 Tasks

We use three forms of tasks in our experiment .the forms is attached with this thesis in appendices .The Arabic version for these tasks forms are in appendices 2 ,4,5,6 from page 110to 114.there are also English version in appendices 14 in pages 129,130.

5.2.2.4 Design

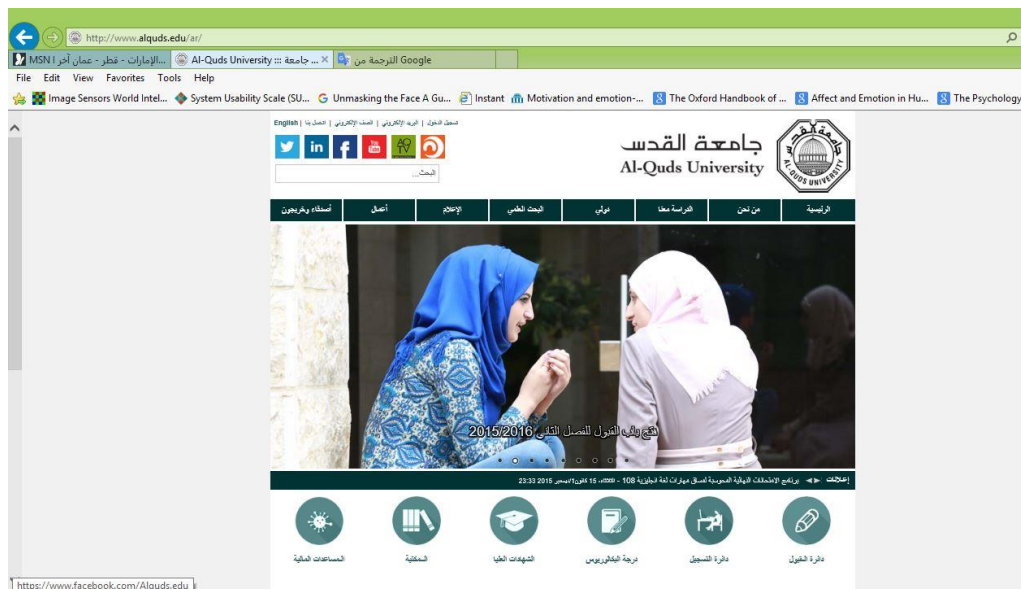


Figure (5-28): The Official Website of Al-Quds University

We chose the official website of ALQUDS UNIVERSITY (<http://www.alquds.edu>) to evaluate user experience for this website. The website has strong points and weak points. The design of the website should target the students of the university (B.A students and M.A students).The tasks are designed to make participants to generate negative and positive emotions, and recorded their emotions by Intel camera. A screen-recording program records every single movement of mouse on screen, and what the user does in the website. At the end of the session and the participant has finished the tasks, mentioned in previous section, the participant fill SUS questionnaire.

5.2.2.5 Procedure (Scenario)

The researcher invites Ahmad to participate in the experiment. Ahmad is B.A student in Al-Quds University. Ahmad agrees to participate and signs the consent form of participate. The researcher prepared a laptop equipped with Intel interactive camera and the necessary software to be used in the experiment. Before starting the experiment, all issues of the experiment are explained, and then the researcher gave Ahmad the task paper that contains three tasks that he should implement on laptop. Ahmad implemented the required tasks on the laptop and while Intel camera was recording Ahmad facial expressions and gestures. In addition, screen-recording program was recording the screen of laptop. After Ahmad had finished the experiment, he filled the paper based SUS questionnaire.

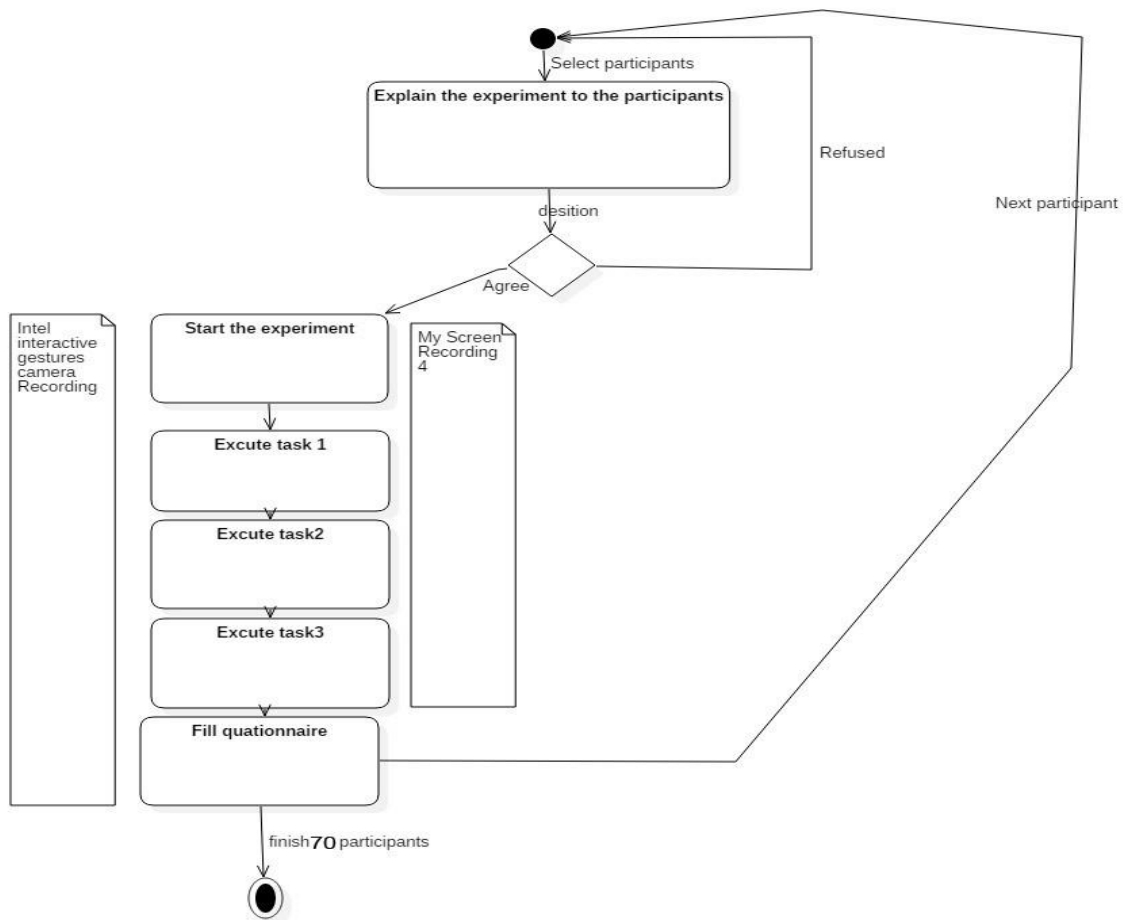


Figure (5-29): Sketch Explain the Procedure of Experiment

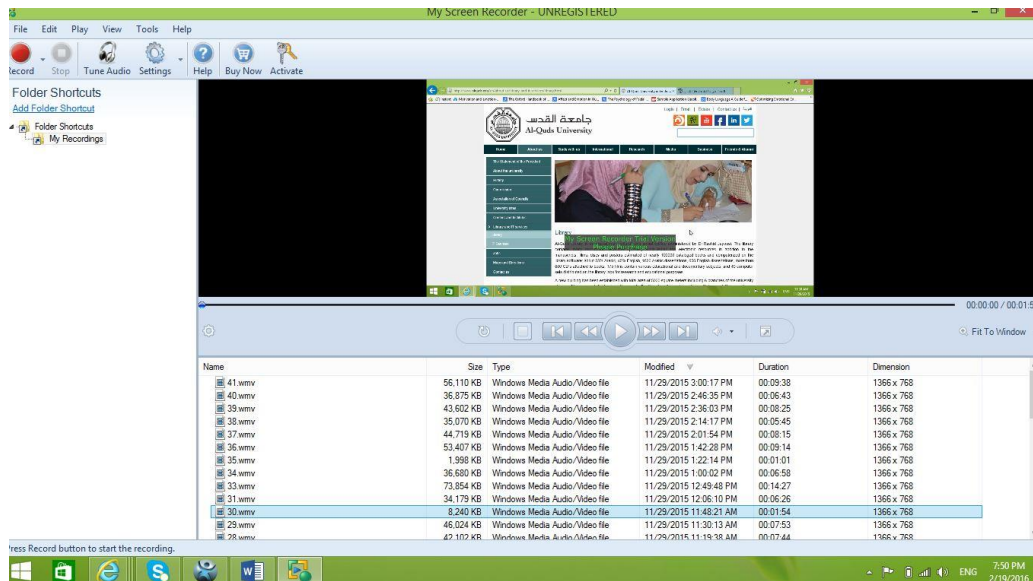


Figure (5-30): Screen Recording Program that record participant desktop

The experiment was implemented on three different places. The first place is at master of computer science study campus at Al-Quds University, in Al-Quds Street –Ramallah-Palestine, the sessions were as follows:

Table (5-11) A : The Sessions of Experiment in Al-Quds University Computer Science Master Study Campus in Al-Quds Street –Ramallah-Palestine

Participant No.	Date	Place	Time	Duration
1	21/11/2015	Al-Quds University Computer Science Master Study Campus -Ramallah	12:27:24 PM	0:13:15
2	21/11/2015	Al-Quds University Computer Science Master Study Campus -Ramallah	1:12:49 PM	0:12:11
3	21/11/2015	Al-Quds University Computer Science Master Study Campus -Ramallah	1:48:07 PM	0:13:40
4	21/11/2015	Al-Quds University Computer Science Master Study Campus -Ramallah	2:01:24 PM	0:12:14
5	21/11/2015	Al-Quds University Computer Science Master Study Campus -Ramallah	2:11:41 PM	0:08:49
6	21/11/2015	Al-Quds University Computer Science Master Study Campus -Ramallah	3:10:07 PM	0:05:00
7	19/7/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	9:31:18AM	0:21:10
8	19/7/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	10:02:06AM	0:23:23
9	19/7/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	10:37:37AM	0:29:28
10	19/7/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	11:03:55AM	0:20:49
11	19/7/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	3:56:33PM	0:25:07

Table (5-11) B : The Sessions of Experiment in Al-Quds University Computer Science Master Study Campus in Al-Quds Street –Ramallah-Palestine

Participant No.	Date	Place	Time	Duration
12	27/8/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	1:01:25PM	0:19:59
13	27/8/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	1:35:25PM	0:20:50
14	27/8/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	2:10:33PM	0:33:11
15	27/8/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	3:05:22PM	0:22:47
16	27/8/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	3:51:49PM	0:19:56
17	1/9/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	2:25:05PM	0:40:34
18	8/9/2016	Al-Quds University Computer Science Master Study Campus -Ramallah	1:12:55PM	0:23:29

The second place for experiment is in Al-Quds university campus of Media and T.V in Al-Quds street –Ramallah –Palestine. The session was as follows:

Table (5-12) : the Sessions of Experiment in the Al-Quds university campus of Media and T.V in Al-Quds street –Ramallah –Palestine

Participant No.	Date	Place	Time	Duration
19	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	9:30:39 AM	0:08:23
20	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	9:40:00 AM	0:09:33
21	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	10:09:27 AM	0:07:22
22	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	10:53:05 AM	0:04:23
23	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	11:06:23 AM	0:07:27
24	23/11/2016	Al-Quds University Campus of Media and T.V -Ramallah	11:18:00 AM	0:05:55
25	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	11:39:51 AM	0:06:45
26	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	11:48:13 AM	0:04:58
27	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	12:10:42 PM	0:03:40
28	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	12:20:14 PM	0:05:17
29	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	12:25:59 PM	0:04:55
30	23/11/2015	Al-Quds University Campus of Media and T.V -Ramallah	12:32:28 PM	0:03:40

The third session was held in Al-Quds University Main Campus in Abu-dies. Please refer to appendix 15 pages 131and 132 to see the sessions .

5.2.2.6 Apparatus

The specifications of the used equipment in our experiment is as follows:

- 1- The Intel interactive gesture camera is installed on Dell laptop XPS L321X (Intel ® Core™ i5-246 M CPU @1.60GHz) with RAM 4 GB. on this laptop
- 2- Sonny laptop VPCEB (Intel ® Core™ i3 M 380 CPU @2.53GHz) with RAM 4 GB
- 3- Intel Creative interactive gesture camera
- 4- Two Caviar portable hard disk

Two laptops were used in the same session. The Dell laptop was used with Intel creative camera for recordings. The version of screen-recording program is 4.12. The participant used Sonny laptop with internet connection.

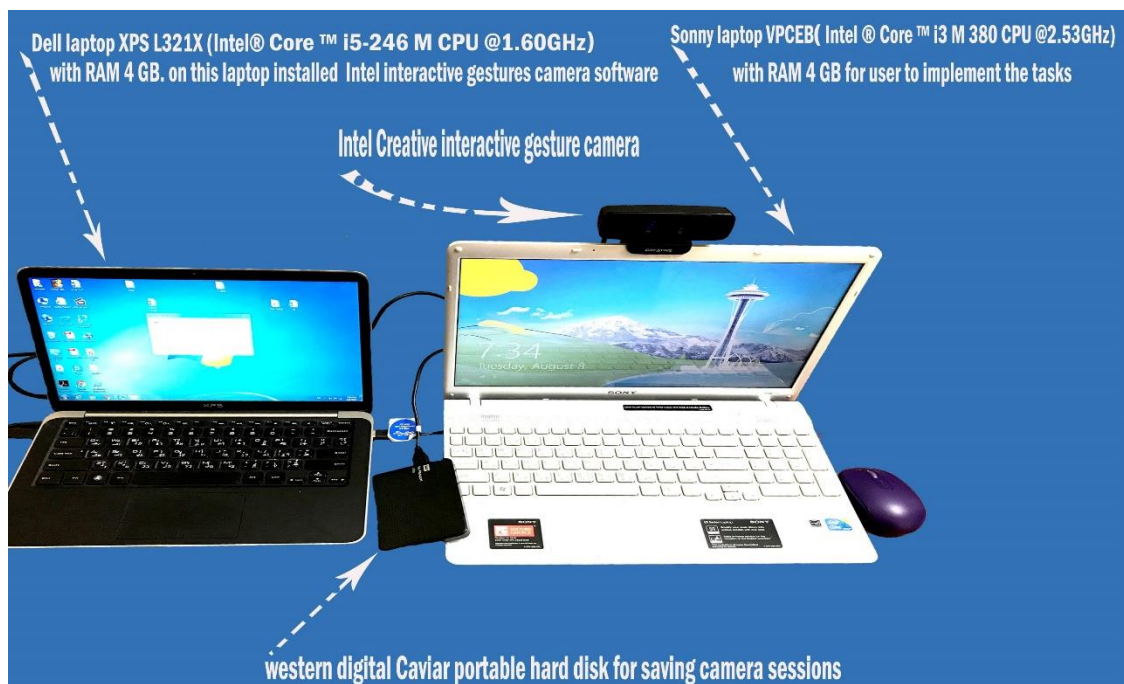


Figure (5-31): Experiment Layout

5.2.2.7 Questionnaire results and analysis

I used system usability scale (SUS) questionnaire that is called “a quick and dirty” scale for usability. *John Brooke* developed SUS questionnaire in 1986. (Brooke, 1990)

SUS is an inexpensive and effective tool for assessing usability for different products like websites, cell phones, interactive voice response systems, TV applications etc. (Bangor et al, 2009). It is an independent technology and has become an industry standard. It is chosen to test hardware, consumer software, websites, cell phones, IVRs and even the yellow pages (Sauro, 2011).

SUS questionnaire consists of 10 items with 5 response options (Likert scale) (Jeff Sauro, 2011). To calculate usability in SUS questionnaire, there are ten items in questionnaire that have odd numbers and even numbers, for odd numbers we should subtract one from participant’s response, and we should subtract the participants’ responses from 5. This operation results in scaling of all values from 0 to 4. Then we add up the results of responses and multiply them by 2.5 to convert the rang from 0 to 100 instead from 0 to 40. The average of SUS score from 500 studies is 68 (Jeff Sauro, 2011). Therefore, any score above 68 is above the average and any score below the 68 is below the average. *Jeff Sauro* has taken raw SUS scores and generated percentile ranks and letter-grades (from A+ to F) for eight different application types. The following graph shows how the percentile ranks associate with SUS scores and letter grades.

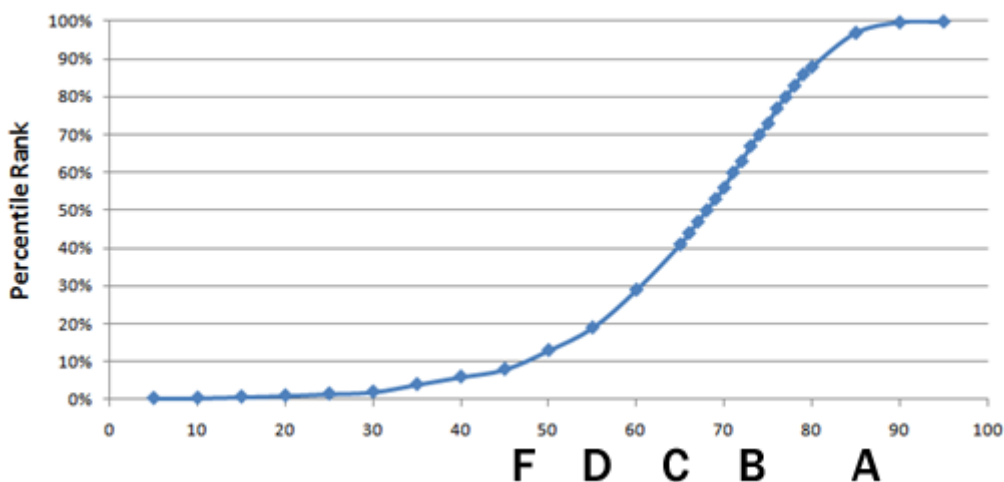


Figure (5-32): How the Percentile Ranks are associated with SUS scores and Letter Grades.

The next table describe the SUS score range, percentiles ranges and its grades symbols:

Table (5-13): The Sauro and Lewis SUS Score Grading (Adopted from Lewis et al , 2015)

SUS Score Range	Grade	Percentile Range
84.1-100	A+	96-100
80.8-84.0	A	90-95
78.9-80.7	A-	85-89
77.2-78.8	B+	80-84
74.1-77.1	B	70-79
72.6-74.0	B-	65-69
71.1-72.5	C+	60-64
65.0-71.0	C	41-59
62.7-64.9	C-	35-40
51.7-62.6	D	15-34
0.0-51.7	F	0-14

We should note that SUS scores are not percentages, but they can be seen as a range from 0 to 100. Technically the 70 out of 100 represent 70 of possible maximum score and indicates that score is at the 70th percentile. In other words, it means that tested application is above average (a score of 70 is closer to average SUS score of 68). Therefore, when we deal with stockholders who are not familiar with SUS score, we need to explain that 70% score really means above average. In our experiment, we built a SUS questionnaire in Arabic language, and we ask the participants to fill it after the experiment.

The following are the summary of questionnaire data:

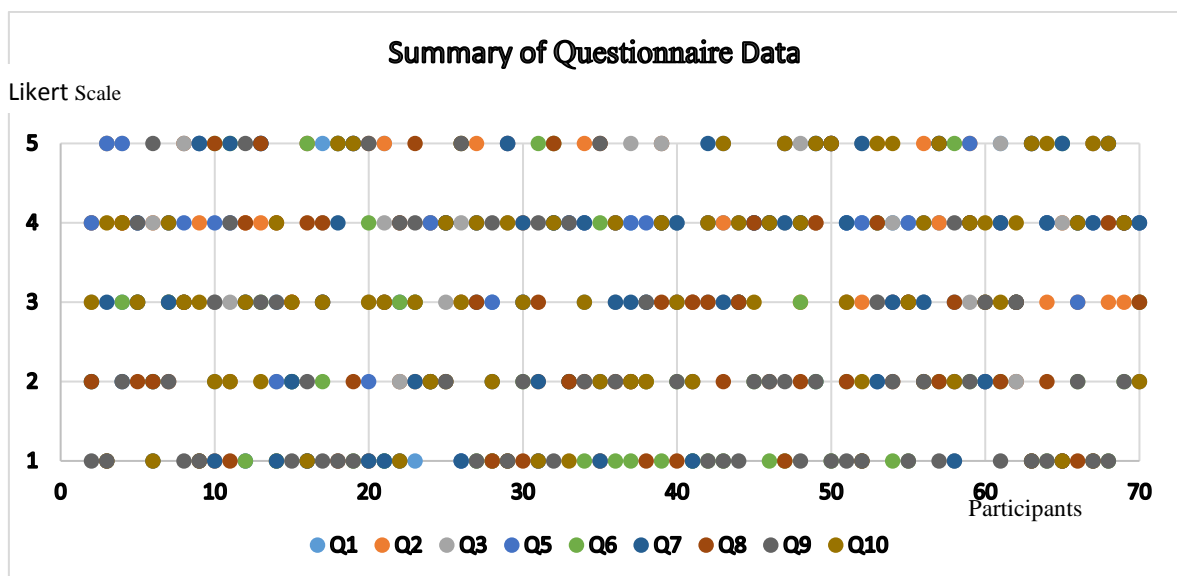


Figure (5-33): Summary of Questionnaire data

When we analyze the 70 questionnaires, we find that the average of usability of all participants is 55.9. This indicates that the percentile rank and letter-grade is D. this means that, the usability score of this application is below the average of usability 68. Moreover, the attitude of the participants indicate bad usability score.

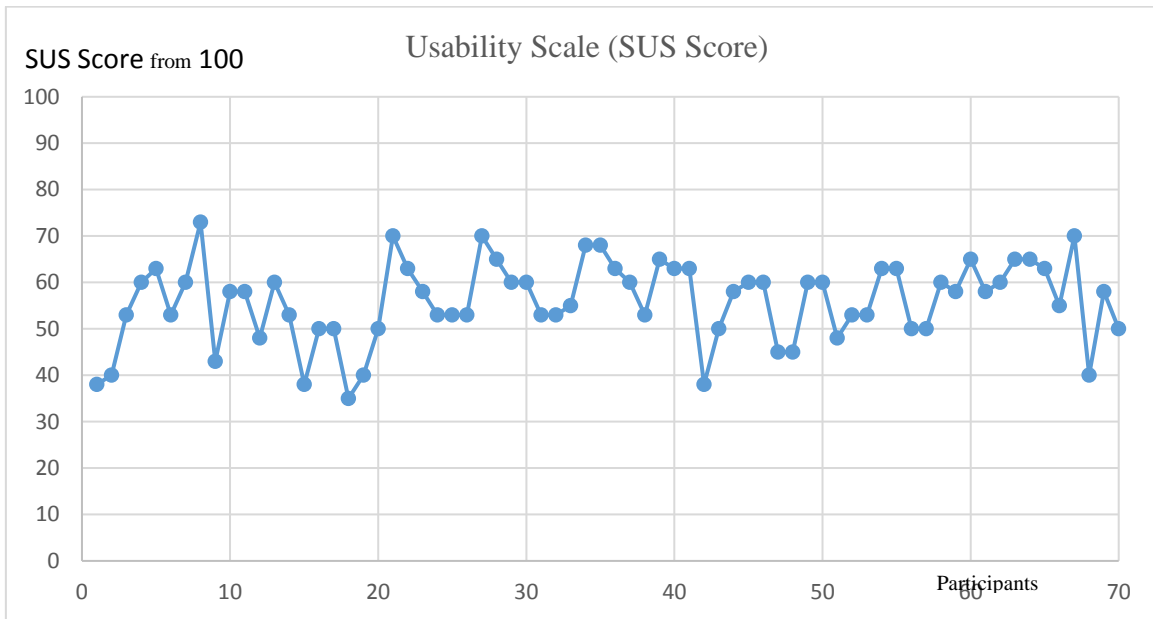


Figure (5-34): Questionnaire Results (SUS score)

5.2.2.8 Camera results and analysis

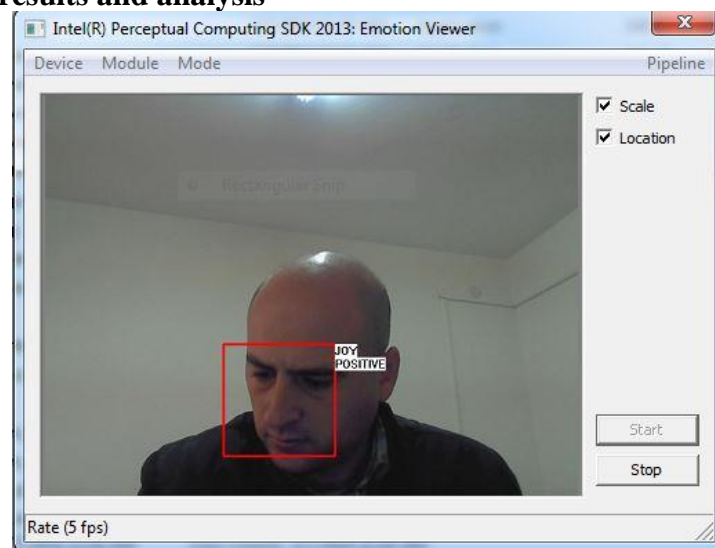


Figure (5-35): One of Participants of Al-Quds University Computer Science Master Study Campus in Al-Quds Street –Ramallah-Palestine

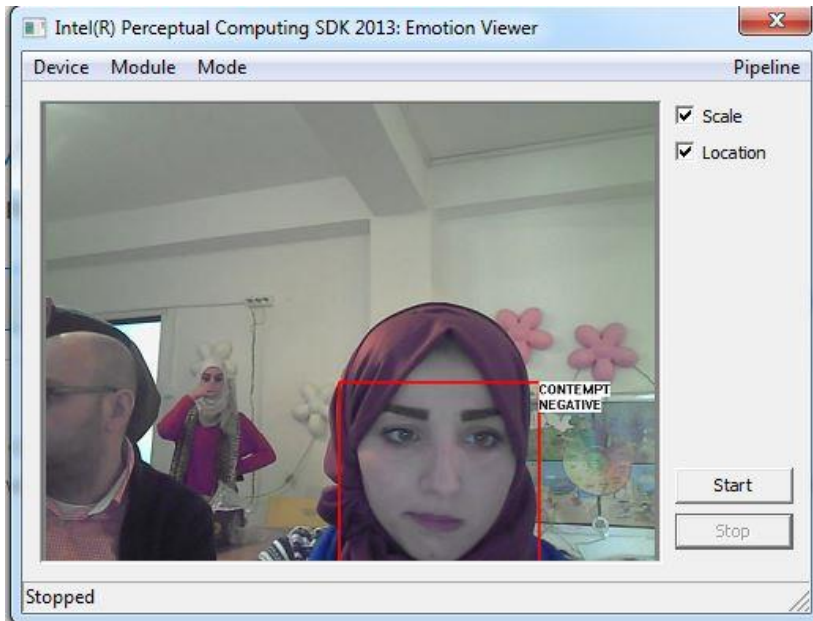


Figure (5-36): One of Participants of al-Quds University of Media and T.V campus in al-Quds Street –Ramallah-Palestine

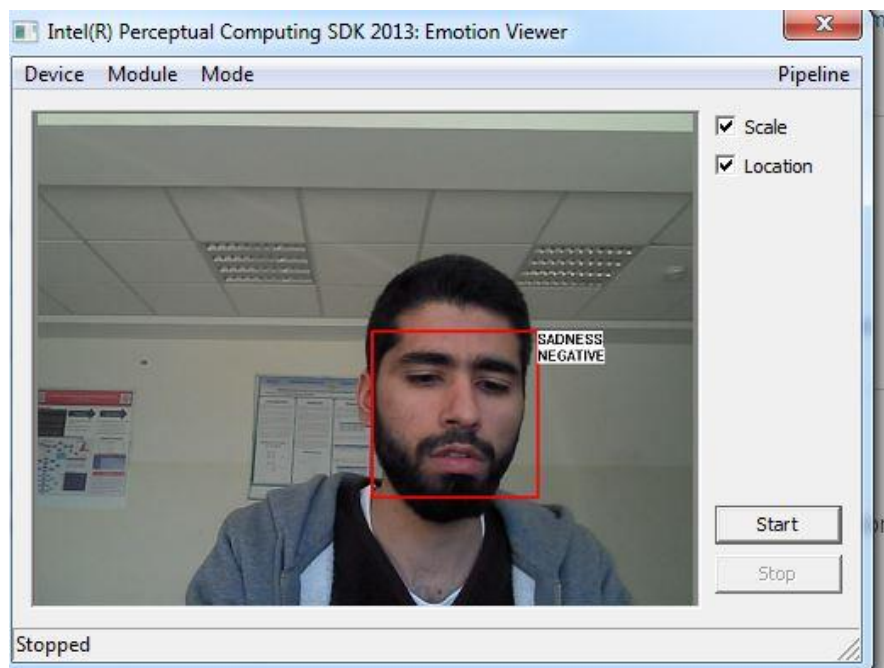


Figure (5-37): One of Participants of Al-Quds University Main Campus in Abu-Dies in Al-Quds -Palestine

We use in our experiment the Intel interactive gesture camera, which classified as perceptual computing. Perceptual Computing is found by the Azerbaijani scientist LOTFI ZADAH (father of fuzzy logic) who worked on building linguistic interfaces using fuzzy sets (https://en.wikipedia.org/wiki/Perceptual_computing,28/7/2017).

We can define the perceptual computing as improvement in IT that enable computers to sense and analyze the Environment around them and response accordingly. (<https://www.techopedia.com/definition/31268/perceptual-computing>, 28/7/2017)

Intel creative interactive gesture camera is a perceptual computing camera designed to interact with computers in a more natural way through facial expression, gestures and voice. We used this camera in our experiment to capture the emotions of participants. The kit of this camera has different examples to capture emotions. (<https://software.intel.com/en-us/articles/developing-applications-using-intel-perceptual-computing-technology>,28/7/2017)

Intel camera change the way user interact with computer, making it more natural, intuitive, and immersive. Computers will be able to perceive our actions through hand gestures, finger articulation, speech recognition, face tracking, augmented reality, and more. To support perceptual computing, Intel introduced the Intel® Perceptual Computing SDK, a library for pattern detection and recognition algorithms. (<https://software.intel.com/en-us/articles/developing-applications-using-intel-perceptual-computing-technology>,28/7/2017)

The Intel Perceptual Computing SDK is a library of pattern detection and recognition algorithm implementations exposed through standardized interfaces. The library aims to lower barriers to using these algorithms and shift the application developers' focus from coding the algorithm details to innovating on the usage of these algorithms for next generation human-computer experience. Intel Perceptual Computing SDK supports different modules related to speech; facial tracking; and close-range tracking which includes finger tracking, hand tracking, gestures, and 2D/3D object tracking. (<https://software.intel.com/en-us/articles/developing-applications-using-intel-perceptual-computing-technology>,28/7/2017)

Intel Perceptual Computing SDK requires a Creative 3D camera, which is small, light-weight, USB-powered camera optimized for close-range interactivity. It is a USB plugin and is designed for ease of setup and portability. It includes an HD webcam, infrared depth sensor camera, and built-in dual-array microphones for capturing and recognizing voice, gestures, and images. (<https://software.intel.com/en-us/articles/developing-applications-using-intel-perceptual-computing-technology>,28/7/2017)



Figure (5-38): Intel Interactive Gestures camera. (Reprinted from (Doss and Raj,2013))

Intel Perceptual Computing SDK finger tracking module tracks hands and finger locations and performs pose/gesture recognition. The module produces four types of processing results: blob information, geometric node tracking result, pose/gesture notification, and alert notification. Geometric nodes are skeleton joints on a human body or those of a localized body part.

We implement facial expressions example to capture emotions, the captured emotions (Anger, Contempt, Disgust, Fear, Joy, Sadness and Surprise), are saved in a text file. Then we take the emotions of each participant and place them in Microsoft Excel file. After that, we count the positive and negative emotions for each participant. I automatically analyzed the usability attitudes of participants depending on the extracted. The results are summarized in the following Figure :

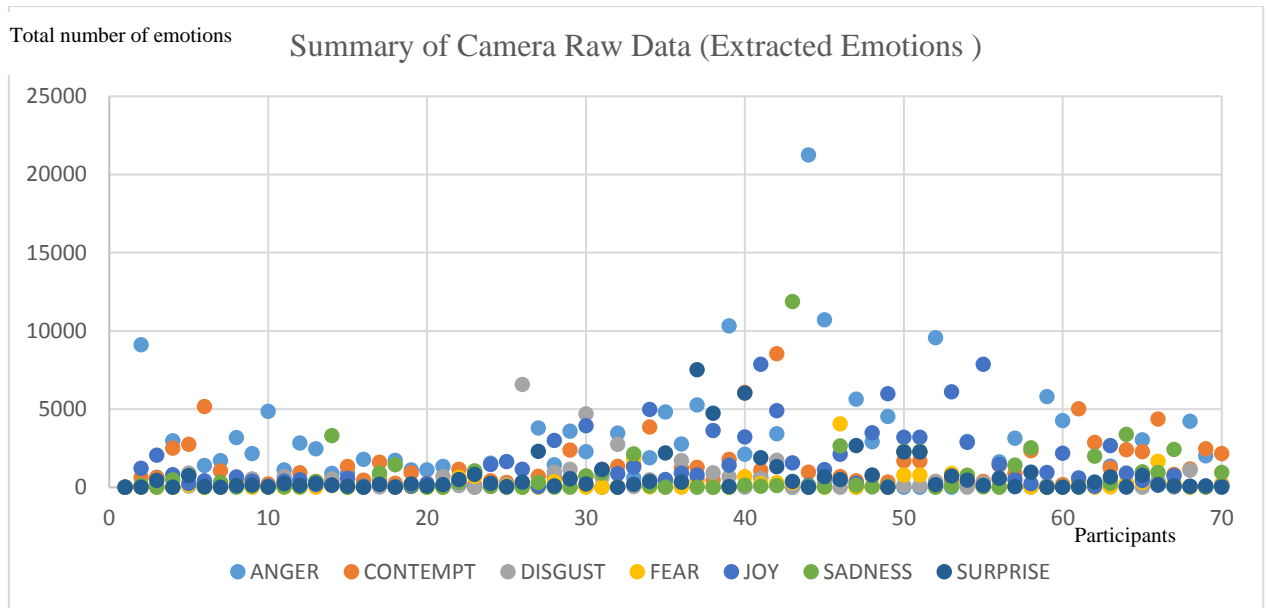


Figure (5-39): Summary of Camera Emotions Data

The above figure contains seven emotions for each participant, and total numbers of these emotions.

After we collect the raw camera data, we should consolidate the data of camera and the data of questionnaire to be compared. The data must be have the same type (like be Likert scale(0-4)). This step is important to compare the data that we extract from camera (count of emotions) with questionnaire data (Likert scale). We will use the SPSS19 to change camera data to frequencies using 20th percentiles (Gay, Airasian ,2003). Based on these frequencies we will create ranges that will represent the Likert scale responses as (1 =Strongly disagree,2=Disagree,3= Natural ,4=Agree and 5Strongly agree) these for negative 6 emotions that we extract (Anger, Contempt, Disgust, Fear, Sadness and Surprise).But for positive emotion that we have (joy) we will do the opposite. We will change the responses to become (5 =Strongly disagree,4=Disagree,3= Natural ,2=Agree and 1= Strongly agree). The final step is to calculate the usability score for camera data like questionnaire data. In previous section we calculate the SUS score or usability score multiply 4(0-4 Likert) by 10

(10 questions) to get score of questionnaire from 40 and to change it from 100 we should multiply by 2.5 . On other hand , For camera to we should multiply 7(emotions)by 4(0-4 Likert) to get score from 28 and to change from 100 we should multiply by 3.57.

The next figure shows camera data after converted to Likert scale:

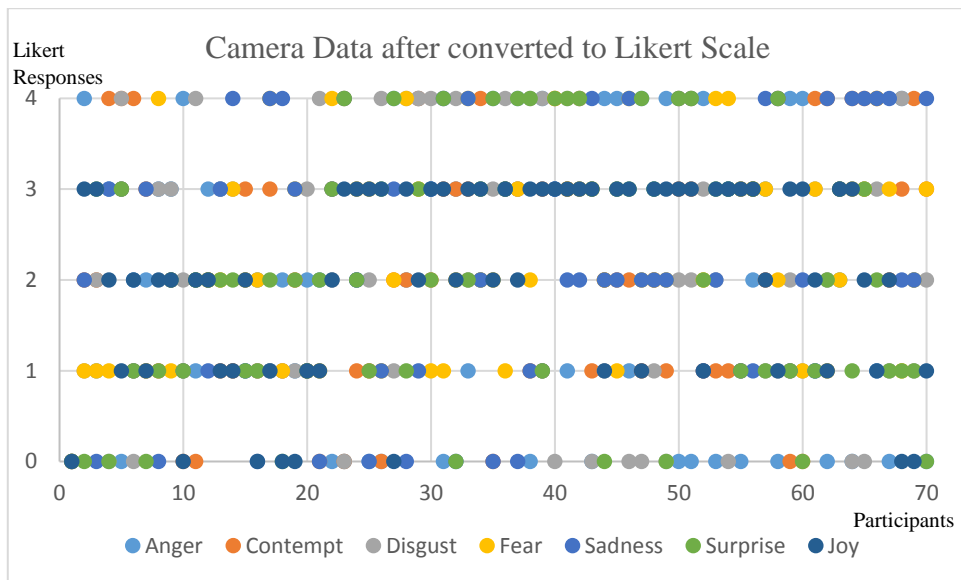


Figure (5-40): Camera Data after converted to Likert Scale

The next figure shows the usability score for camera data from 100:

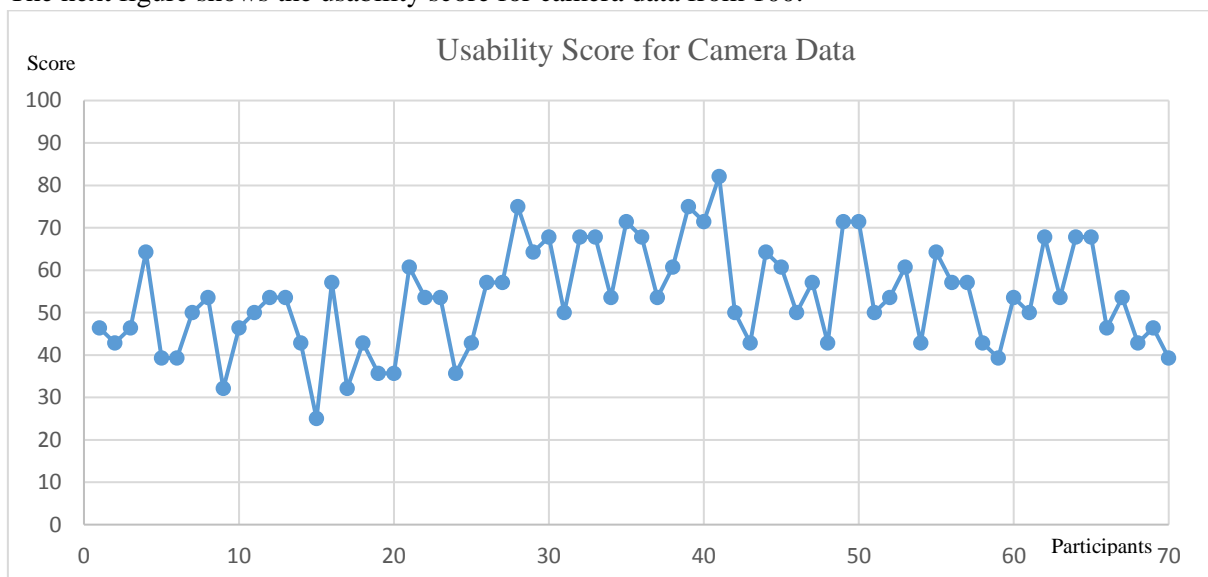


Figure (5-41): The usability score of camera data from 100

5.3 Discussion

The main aim of experiment is to find a new valid tool to measure usability or user experience in automatic way that can be more sensitive and easier than SUS paper based questionnaire. To achieve our goal we use two valid tools; Intel interactive gesture camera and SUS (System Usability Score) questionnaire to measure the usability and user experience of Al-Quds University website.

We infer that, there is a total agreement between the usability results of the questionnaire and the usability results of the camera. To show the total agreement between the results, we will explore the quantitative and qualitative data for both camera data and questionnaire data. For quantitative data the next table is contain the basic statistical information about the SUS questionnaire usability score (from 100) and camera usability score (from 100) ,Participants(N)=70.

Table (5-14): Basic statistical information for usability about SUS and camera

Statistics	Mean	Median	Standard Deviation	Variance	Minimum	Maximum	Average
SUS Questionnaire Usability Score	55.68	57.50	8.732	76.254	35	73	55.9
Camera Usability Score	53.4990	53.5500	12.07197	145.733	24.99	82.11	53.5

The above table shows that basic statistical information for both the SUS questionnaire usability score and camera usability score are very close and the camera can be a good alternative for SUS questionnaire.

The Cronbach alpha, which refers to reliability of measurements, is estimated as 0.498 for questionnaire data and 0.373 for camera data. These values indicate the strength of questionnaire and camera as instruments used in the evaluation (Harrati, Bouchrika, Tari, Ladjailia, 2016). The SUS questionnaire is a valid measure tool for more than 25 years (Brooke, 2013). On the other hand, Intel interactive gestures camera and its application that we used is built on FAPs model. So, the two tools that we use are concurrent valid tools.

There are many ways to express SUS usability scores like acceptability ranges, adjective rating and grade scale. In 2009 Bangor, Kortum and Miller have studied 3,500 SUS scores over one decade for different systems and technologies. They found a relation and correlation between SUS scores and people evaluate systems and products. People who evaluate systems and products use adjectives like good, excellent and poor. On the other hand, they use a scoring system ranging from 0 to 100 to interrupting SUS scores as percentage, but it is not interrupted (Brooke, 2013). The using of percentiles scores which give a more meaningful interrupting for SUS score (Sauro, 2011) (Bangor, Kortum and Miller, 2008). The next figure showing the original image of grade rankings of SUS scores from "Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale," by A. Bangor, P.T. Kortum, and J.T. Miller, 2009, Journal of Usability Studies.

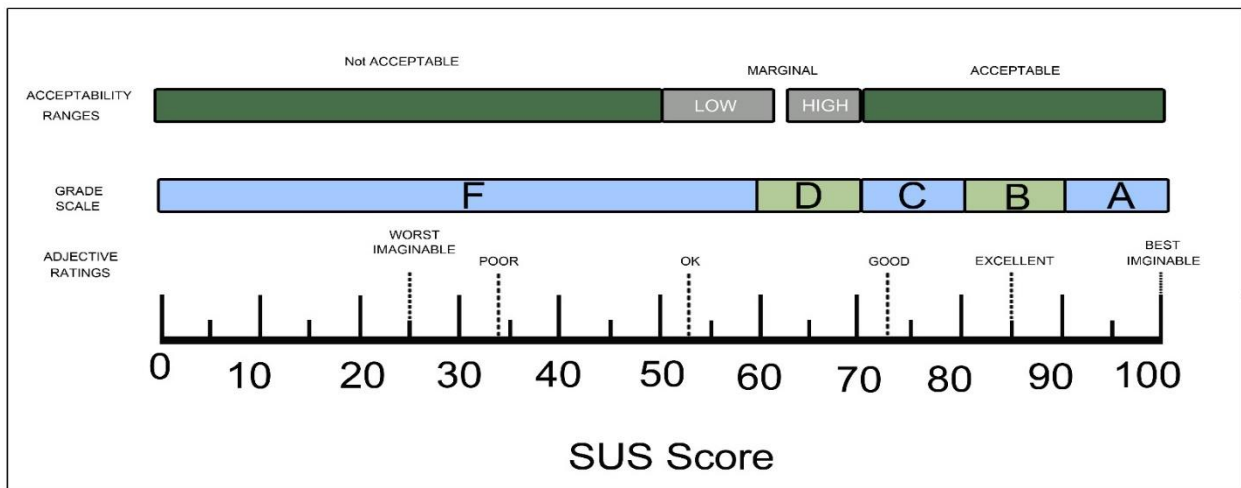


Figure (5-42): Grade Rankings of SUS Scores (Bangor & et al, 2009)

Implementing (Bangor, Kortum, and Miller) on our results of experiment (SUS and camera) we can get the next figures :

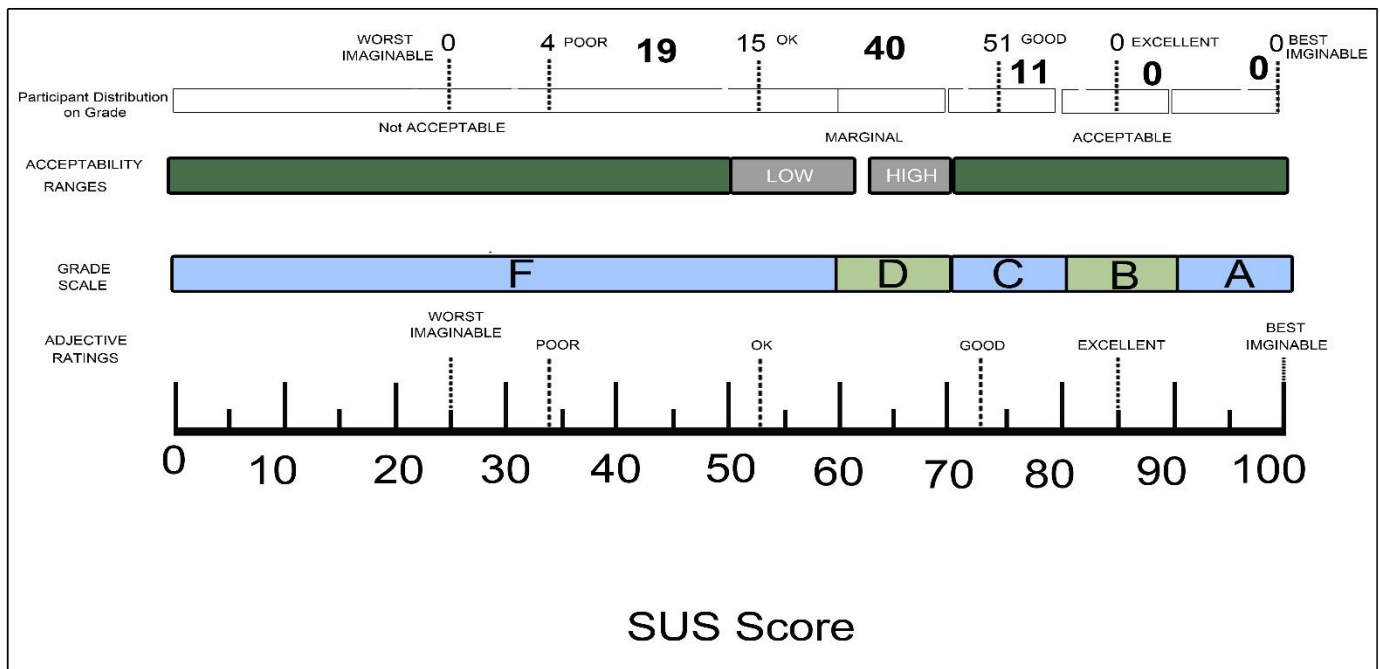


Figure (5-43): SUS Questionnaire Score results of our experiment

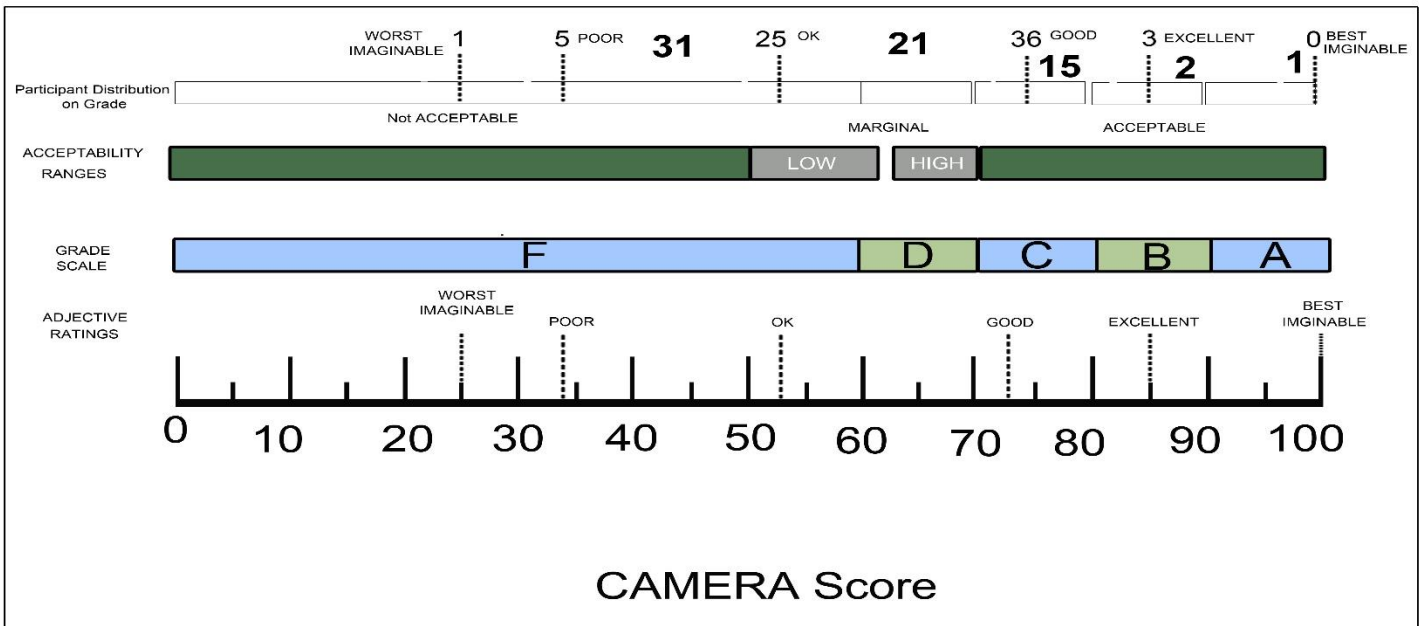


Figure (5-44): Camera Score results of our experiment

Implementing the Sauro and Lewis SUS Score grading (2015) (see table (5-14)) on usability score results of questionnaire and camera we will get the next figure:

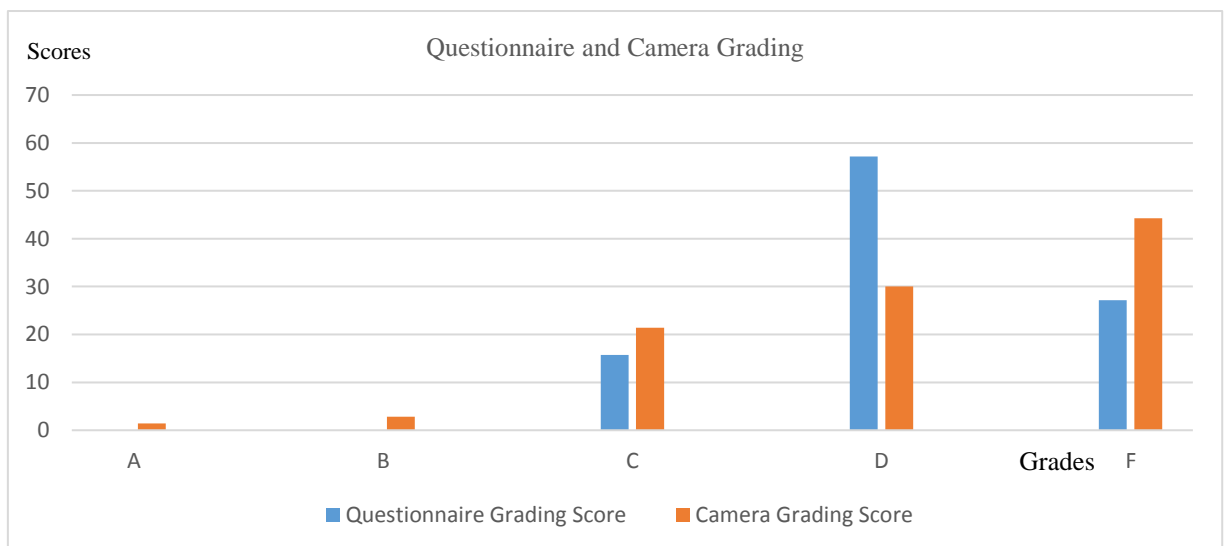


Figure (5-45): The questionnaire and camera usability grading score

In figure (5-42), we see how the scores grades are distributed for camera and questionnaire from 100. Beside, we notice that camera is more sensitive than questionnaire in capturing usability.

The qualitative data that we collected through the sessions with users are indicate that the users opinion is support the usability results of camera and questionnaire .As we mentioned the usability average score of SUS questionnaire is 55.9 and for camera is 53.5. These averages indicate that usability is below average (68) depending on (Sauro, 2011) (Bangour, Kortumand and Miller, 2008). In interviews, the participants have present key comments about the website of Al-Quds University. We asked the participants about the usability of website by mentioned the negative and positive points in site .One participant stated :(There are many negative points like moving between pages and update critical information on e-class) another participant stated :(I think the worst thing in website finding the desired link that I want to use and unclear icons that used in site to instruct the user). When we asked participant about the degree of ease and difficulty to access information from the website. He said (the degree of ease to access information is below median) .In general, the participants have impression that website have some complicated in usability issues and should work to improve the site.

6 Chapter Six : Conclusions and Future Work

6.1 Conclusions

Human-computer interaction does not depend on traditional input devices, but it has exceeded the normal limits and has become very close to human–human interaction. In human–human interaction, the facial expressions and human gestures are the basic part of interaction beside the speech. Facial expressions and gestures have also become the basic part of human-computer interaction. Keyboard, mouse and other input devices have become old interaction tools, the new interactions tools are facial expressions and gestures like raising right eyebrow, raising left eyebrow, smiling etc. These new interaction tools are also indicators to evaluate usability or user experience of any computer application or program. This hidden relation between emotions and body language that include (facial expression and gestures) gives the researchers the opportunity to investigate the affect state of human who uses computer device without explicitly communicating with it. Personally think that reading of nonverbal cues of user makes the evaluation operation of any application more efficient and more accurate while it decreases annoyance to the user. The emotions or digitally transformed/converted emotions that result from the human–computer interactions have the same characteristics and aspects of emotions that results from human–human interactions, and we can use the same category approaches of emotions to implement them on digitally transformed/converted emotions. Therefore, methods for monitoring these digitally transformed/converted emotions can be developed and using these digitally transformed/converted emotions in measuring the usability of applications. Digitally transformed/converted emotions can be a good and a clear indicator to usability of any application.

We can infer digitally transformed/converted emotion by traditional ways from psychological behavior through blood pressure, eyelid, etc. but these traditional methods have problems make it not identical for use. The alternative methods that depend on reading the emotions by body language (facial expressions and gestures)like Facial action coding system FACS that can be used in psychology and in computer science and the closet one to this model is MPEG or Facial Animation Parameter used only in computer science. Moreover, we can use hand over face gestures using the analysis method used by *Mahmoud and Robinson*.

This research evolve new model (MUDE) depending on the methods (FACS, FAP and *Pease & Pease*) that inferring digitally transformed /converted emotions that results from human –computer interaction . MUDE Model can be used to measure the User Experience of user using the expected emotions that user expressed before, during and after interaction with application or software. This new model makes the way of measuring so natural and not bothering users during the evaluation and measuring process. In addition, it provides us with the needed information without asking users. Furthermore, it is more accurate and truthful way, by which the researcher can determine the usability of application and user experience of user.

The method can be used to measure the impression of any human not only in HCI domain, but also in diverse domains like coffee shops, to take impression of customers about new drinks. We can also use the model in airports to take feedback from passengers about services that have been served to them. I think that this model will have a wide range of uses in different domains. Beside the model this thesis introduce a new experiment that implement the MUDE model and find a new valid tool to measure usability or user experience in automatic way that can be more sensitive and easier than SUS paper based questionnaire. To achieve our goal we use two valid tools; Intel interactive gesture camera and SUS (System Usability Score) questionnaire to measure the usability and user experience of Al-Quds University website. The qualitative data in experiment that we collected through the sessions

with users are indicate that the users opinion is support the usability results of camera and questionnaire .As we mentioned the usability average score of SUS questionnaire is 55.9 and for camera is 53.5. These averages indicate that usability is below average (68) depending on (Sauro, 2011) (Bangour, Kortumand and Miller, 2008).So, the results give us indicator that camera can be valid tool to user experience and usability and there is a new way to develop new accurate and reliable methods.

This field of new interactions have its principles and rules that should be studied to successfully extract the accurate indications and meaning of the facial expressions and human gestures, in order to develop applications and programs that are capable of understanding these cues.

To fully understand this subject, we must have a sufficient knowledge of models like *Ekman* and FAPs. We need to develop new models to enhance the overall operation cycle; also, we have experimental proofs that these new interactions tools are real sources of usability and user experience data.

6.2 Future Work and limitations

Through this thesis, we concluded that the human–computer interactions tools have advanced to become very close to human–human interactions. We should work on new models to contribute in the development of human–computer interactions. On the other hand, we should work hard to develop new applications and programmers that are compatible with these interactions. We need to concentrate on applications utilizing from emotions extracted from facial expressions and gestures to evaluate usability and user experience without bothering the users. However, there are many limitations and constraints like hardware slow improvement in the domain of monitoring facial expressions and gestures. A limited number of companies manufacture the monitoring hardware tools. Another limitation is that sometimes the facial expressions of users do not indicate the real psychological state of human, in some situations the facial expressions shows sadness expression, while in reality the human may not be in this situation. The third limitation is that facial movements is only one of other nonverbal cues, but we need to consider the all-nonverbal cues that occur to understand the real psychological state. The next limitation is that people faces are different, some have expressing faces, others do not have clear expressing faces that are difficult to

read, and hence hardware tools like camera will not be completely accurate. The final limit is that reading facial expressions and gestures is not acceptable for people in some societies, and may be considered a controversial topic in some cultures.

Finally, I want to mention that the number of researches in this field is limited.

On the other hand, there are many open roads to future work there main way to work on hardware of Intel interactive gestures camera to develop it to be more accurate, specific and sensitive. There is main way to develop its applications like developing new application that give us the usability and user experience of any application directly comparing with SUS questionnaire .

The third main way is working on MUDE model, which needs developing, and more become widely to cover more areas like evaluate the satisfaction of customers about any service in cafe or restaurant.

6.3 Problems:

- 1- The research topic is very difficult and have limited number in references.
- 2- The camera that I used (Intel interactive gesture camera) take long period to be imported (about 6 months).
- 3- Many people refused to participate in the experiment (especially girls).
- 4- No budget for scientific research in Al-Quds University.
- 5- This research needs full time researcher to accomplish the research.

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تجربة المستخدم والمشاعر المتولدة/ المستخلصة رقميا

أعداد: محمد رأفت محمد عودة

المشرف: د. بديع سرطاوي

ملخص الدراسة

تشتمل هذه الأطروحة على دراسة لتصورات المستخدم وردة فعله "تجربة المستخدم" و"الاستخدامية" على استخدامه لتطبيق أو برنامج عن طريق العواطف والاحاسيس والمشاعر الداخلية للمستخدم التي تنعكس على الايماءات المتمثلة بملامح الوجه وحركات الجسد. فالإنسان يتواصل مع اقرانه عن طريق الكلام والمخاطبة الى جانب الايماءات التلقائية التي تظهر على ملامح الوجه وحركات اليد والجسد. وهذه الايماءات تعكس وتوضح المكونات العاطفية والمغزى الخفي من الكلام والمخاطبة والحوار. فالإيماءات التي تواكب عملية الكلام والمخاطبة هي مكون مكمل لعملية التواصل والتفاعل التي يقوم بها الانسان مع الانسان.

فهذه الدراسة تدرس عملية مشابه لعملية تواصل وتفاعل الانسان مع الانسان وهي عملية تواصل وتفاعل الانسان مع الحاسوب. فالإنسان يقوم بالتعبير عن نفسه بالكلام والايماءات اما الحاسوب فهو لا يستطيع التعبير عن نفسه ولا يستوعب أي حديث من الانسان. ولكن خلال عملية تفاعل الانسان مع تطبيقات وبرامج الحاسوب تتولد لدى الانسان مشاعر من الرضى والسخط حسب أداء البرنامج في الحاسوب والتي تسمى المشاعر المتولدة رقميا.

نقوم في هذه الدراسة بتحديد هذه المشاعر المتولدة رقميا "الإيجابية والسلبية" عن طريق الايماءات "ملامح الوجه وحركات الجسد" لكي نستدل بها على مقياس الاستخدامية وتجربة المستخدم.

نستعرض في هذه الدراسة الإشارات الخاصة بسلوك الانسان (اللفظية وغير اللفظية) ومعنى المشاعر الرقمية. كما سنتعرف على قنوات البث الخاصة بالمشاعر لدى البشر والطرق والأساليب والنماذج التي تستخدم في استنتاج هذه المشاعر والعواطف عن طريق تحليل الايماءات الخاصة بالبشر. سوف نتعرف على معاني الاستخدامية وتجربة المستخدم والفروق بينهما.

تقدم هذه الدراسة نموذج جديد يسمى (مودي MUDE) يستخدم في تحليل الايماءات بطريقة جديدة لتحديد العواطف. كما ستقدم تجربة جديدة في قياس الاستخدامية وتجربة المستخدم باستخدام الكاميرا الذكية من شركة انتل التي تستدل على المشاعر وتحول جهاز الكمبيوتر الى جهاز تفاعلي ممكن ان يقرأ المشاعر. وسنقوم بعمل مقارنة بين نتائج الكاميرا واستبيان خاص بقياس الاستخدامية (SUS).

Appendices:

Appendix 1: Research Consent Form, Personal data, Background and Questionnaire

اتفاقية مشاركة بين المستخدم وبين الباحث

أوافق أنا الموقع أدناه على المشاركة في تقييم تطبيق ا و ذلك ضمن دراسة يجريها الباحث استكمالاً لمتطلبات التخرج للحصول على درجة الماجستير .

لقد تم شرح فكرة التجربة لي بوضوح ، و قمت بقراءة النص التعريفي لفكرة التجربة ليبقى لمعرفتي الشخصية فقط و سأحافظ على سرية المعلومات المعطاة لي و أوافق على المشاركة بالشروط التالية:

1. أن أقوم بالتجربة تحت ملاحظة الباحث نعم لا
2. أن يتم تصويري صور ثابتة أثناء التجربة وتعبئة الطالب نعم لا
3. أن يتم تصويري بالفيديو أثناء التجربة وتعبئة الطالب نعم لا
4. أن يتم مقابلتي لأخذ ملاحظاتي من قبل الباحث بعد التجربة وتعبئة الطالب نعم لا
5. أن أقوم بتعبئة استمارة التقييم بعد التجربة نعم لا

أنا أفهم بوضوح ان مشاركتي في هذا التجربة هي مشاركة تطوعية، و ان بإمكانني عدم المشاركة في جميع مراحل المشروع، و ان بإمكانني الانسحاب في أي وقت أشاء و انه لن يفرض علي اي عقاب او لوم بسبب انسحابي او انه لن يتم استثنائي في اي نشاط اخر ارغب بالمشاركة به بسبب ذلك.

أنا أفهم بوضوح ان جميع المعلومات التي سيتم تسجيلها من ملاحظاتي أثناء التقييم سترد في تقرير تقييم المشروع دون الاشارة الى شخصيتي او التعريف بي. و ان معلوماتي الشخصية لن يتم مشاركتها مع اي طرف اخر غير الوارد في هذا الاتفاق على الاطلاق و انه سيتم اتلاف هذه الملفات المشيرة الى شخصي حال الانتهاء من المشروع.

إسم المشارك :

التوقيع:

التاريخ:

إسم المقابل:

المعلومات الشخصية

الإسم:

العمر: _____ الجنس: ذكر أنثى

المستوى الأكاديمي: بكالوريوس أولى ثانية ثالثة رابعة خامسة مؤهل

ماجستير أولى ثانية ثالثة رابعة مؤهل

دكتوراه باحث مؤهل

التخصص:

البريد الإلكتروني:

خلفيتك في استخدام الحاسوب

1. هل أنت من مستخدمي الحاسوب لغرض الدراسة أو التدريس؟

لا __ نادرا __ أحيانا __ بشكل شبه يومي.

2. كم من الوقت تقضي في استخدام الحاسوب؟

__ 8 ساعات يوميا او أقل __ 4 ساعات يوميا أو أقل __ أقل من ساعتين يوميا __ أقل من 4 ساعات أسبوعيا

3. هل استخدمت سابقا او تستخدم حاليا نظام تشغيل غير نظام ويندوز؟

4. __ لا __ نعم

الخبرة في استخدام الانترنت

1. هل أنت من مستخدمي الانترنت؟

لا __ نادرا __ أحيانا __ بشكل شبه يومي.

إذا كانت الإجابة (لا) انتقل الى الجزء الثالث من الاستبيان.

2. ما هي فترة خبرتك في استخدام الانترنت؟

___ أقل من يوم ___ أقل من أسبوع ___ أقل من شهر ___ أقل من 6 شهور
 ___ تقريبا سنة ___ تقريبا سنتين ___ تقريبا 3 سنوات ___ أكثر من 3 سنوات

3. ما هي أكثر المواقع التي تستخدمها خلال استخدامك للانترنت

___ المواقع الاجتماعية ___ البريد الالكتروني ___ المواقع الاكاديمية ___ الإستبيان
 ___ جميعها ___ لا أستخدام أي منها

تقييم تجربة استخدام التطبيق لا أوافق أوافق

5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1

1. هل تعتقد ان استخدام التطبيق سهل؟

2. هل ترغب باستخدام التطبيق مرة اخرى؟

3. هل بنود التطبيق واضحة وسهلة؟

4. هل تعتقد انك تحتاج للمساعدة خلال استخدام التطبيق؟

5. هل وجدت ترابط بين أجزاء التطبيق؟

6. هل وجدت تضارب في بنود التطبيق؟

7. هل تعتقد ان كثيرا من الناس بإمكانهم استخدام التطبيق؟

8. هل شعرت بانك تحتاج لتعلم أشياء كثيرة للتعامل مع التطبيق؟

9. هل ترى ان هذا التطبيق صعب التعامل معه؟

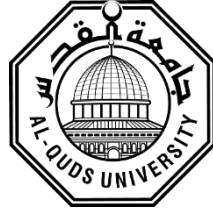
10. هل الطلاب بشكل عام يتبنى احتياجاتي ورغباتي؟

نكتفي بهذا الكم من الاجابات و نشكر لكم تعاونكم معنا، اذا كان لديكم وقت اضافي للمساهمة في آرائكم لإيجاد

حلول تتناغم مع انتقاداتكم، وفي النهاية اتقدم انا الباحث إلى كل من قام بتعبئة هذا الإستبيان بالشكر والتقدير .

الباحث

محمد رأفت عودة



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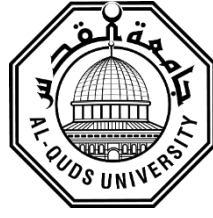
Task form for (Master Students in Al-Quds University)

عزيزي المشارك المحترم

ارجو من حضرتك تنفيذ المهمات التالية:

- 1- أدخل الى الموقع الخاص بجامعة القدس (www.alquds.edu) ((النسخة العربية وحاول البحث والحصول على اخر المنشورات البحثية الخاصة بالدكتور بديع السرطاوي. حاول مرة أخرى باستخدام النسخة الإنجليزية للموقع.
- 2- ارجو من حضرتك المحاولة للحصول على وصف لمساق (أنظمة تشغيل متقدمة) علما انه من مساقات الدراسات العليا الخاصة بعلم الحاسوب. الرجاء استخدام النسخة العربية في المحاولة الأولى واستخدام النسخة الإنجليزية في المحاولة الثانية.
- 3- الرجاء الدخول الى موقع المكتبة الالكترونية الخاصة بجامعة القدس واستخدام محرك البحث الخاص بها للبحث عن رسالة ماجستير خاصة بموضوع ال Datamining. ارجو المحاولة باستخدام النسخة العربية وقم باستخدام النسخة الإنجليزية للمحاولة الثانية.

الشكر الجزيل لتعاونكم



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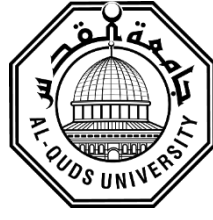
Task form for (T.V and Media Students in Al-Quds University)

عزيزي المشارك المحترم

ارجو من حضرتك تنفيذ المهمات التالية:

- 1- أدخل الى الموقع الخاص بجامعة القدس (www.alquds.edu) ((النسخة العربية وحاول البحث والحصول على بيانات الاتصال (رقم الهاتف والبريد الالكتروني) الخاصة بعضو هيئة التدريس الدكتور جمال سرحان. حاول مرة أخرى باستخدام النسخة الإنجليزية للموقع.
- 2- ارجو من حضرتكم المحاولة للحصول على وصف لمساق (فنون الصحافة والاعلام 1) علما انه من مساقات الاعلام والتلفزة. الرجاء استخدام النسخة العربية في المحاولة الأولى واستخدام النسخة الإنجليزية في المحاولة الثانية.
- 3- الرجاء الدخول الى موقع المكتبة الالكترونية الخاصة بجامعة القدس واستخدام محرك البحث الخاص بها للبحث عن كتاب يحمل عنوان الاعلام المعاصر. ارجو المحاولة باستخدام النسخة العربية وقم باستخدام النسخة الإنجليزية للمحاولة الثانية.

الشكر الجزيل لتعاونكم



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Task form for (B.A Students in Al-Quds University)

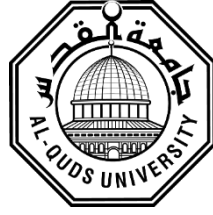
عزيزي المشارك المحترم

ارجو من حضرتك تنفيذ المهمات التالية:

- 4- أدخل الى الموقع الخاص بجامعة القدس (www.alquds.edu) ((النسخة العربية وحاول البحث والحصول على معلومات الاتصال الخاصة بالدكتور بديع السرطاوي علما انه عضو تدريس في كلية العلوم والتكنولوجيا (دائرة الحاسوب وتكنولوجيا المعلومات) . حاول مرة أخرى باستخدام النسخة الإنجليزية للموقع.
- 5- ارجو من حضرتكم المحاولة للحصول على وصف لمساق (أنظمة تشغيل متقدمة) علما انه من مساقات الدراسات العليا الخاصة بعلوم الحاسوب. الرجاء استخدام النسخة العربية في المحاولة الأولى واستخدام النسخة الإنجليزية في المحاولة الثانية.
- 6- الرجاء الدخول الى موقع المكتبة الالكترونية الخاصة بجامعة القدس واستخدام محرك البحث الخاص بها للبحث عن رسالة ماجستير خاصة بموضوع جامعة القدس المفتوحة . ارجو المحاولة باستخدام النسخة العربية وقم باستخدام النسخة الإنجليزية للمحاولة الثانية.

الشكر الجزيل لتعاونكم

Appendix 5: Task form for (Master Students in Al-Quds University)



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Task form for (Master Students in Al-Quds University)

المهمة رقم (1)

نظرا لأهمية التخصص الذي تقوم بدراسته في بناء وتنمية المؤسسات الفلسطينية نرجو من حضرتك البحث عن معلومات من خلال موقع جامعة القدس عن دور الجامعة في مجال تخصصك (بناء وتنمية مؤسسات) من حيث فعاليات، توقيع اتفاقيات، ورشات عمل، طرح برامج، مشاريع تخرج تؤدي الى تحسين أوضاع المؤسسات الفلسطينية.

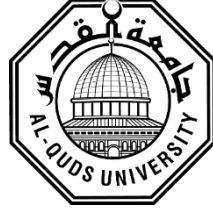
المهمة رقم (2)

نرجو من حضرتك البحث عن معلومات عامة حول اهداف هذا البرنامج الذي تقوم بدراسته والاطلاع على المسابقات المطروحة بالإضافة الى الاطلاع على ملفك الأكاديمي من علامات ومسابقات مجتازة. وما تم إنجازه من ساعات بنجاح حسب الخطة الدراسية المعتمدة في التخصص الذي تدرسه.

المهمة رقم (3)

من خلال دراستك في مجال تنمية وبناء المؤسسات لا بد وأنت بدأت تفكر في الرسالة او مشروع التخرج المطلوب منك كطالب دراسات عليا (اذا لم تختار الذهاب الى امتحان شامل). إذا كنت قد اخترت مساق الرسالة. ارجو من حضرتك البحث عن الأساتذة الأقرب الى الفكرة التي تدور في ذهنك او جملة الأبحاث التي يعملون عليها ولخصها بعدد من الكلمات بحيث تشمل اسم الدكتور وتخصصه والاهتمامات البحثية.

Appendix 6: Task form for (B.A Students in Al-Quds University)



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Task form for (B.A Students in Al-Quds University)

عزيزي الدارس ارجو من حضرتك تنفيذ المهام التالية :

- 1- تصفح موقع الجامعة www.alquds.edu بشكل عام وكون فكرة عن التخصصات الموجودة في كل من :
 - 1- كلية المهن الصحية
 - 2- كلية العلوم
 - 3- كلية الهندسة
- 2- حسب تخصصك نرجو منك الدخول الى موقع الجامعة وتصفح المعلومات حول البرنامج واعطاء فكرة بسيطة عن اعداد الاساتذة كم منهم ذكور وكم منهم اناث.
- 3- الدخول الى صفحة ال E-class وتحميل ال Syllabus لاحد المساقات المطروه في هذا الفصل
- 4- الدخول الى موقع الطلب وعرض البرنامج الفصلي
- 5- الدخول الى صفحة الانشطة الطلابية واعطاءه فكرة بسيطة عن اهم الانشطة التي يقوم بها طلاب الجامعة .
- 6- الدخول الى صفحة الاخبار والبحث عن اخر اربعة اخبار تم نشرها من حيث نوع الخبر و تاريخ نشره وعلاقته في الجامعة .
- 7- هناك طالب بحاجة الى معلومات حول تخصص الطب المخبري في الجامعة .من خلال تصفحك على صفحة الجامعة هل يمكنك الاجابة عن الاسئلة التالية:
 - 1- طبيعة هذا التخصص.
 - 2- شروط القبول في التخصص
 - 3- عدد المدرسين
 - 4- تحت اي كلية يدرج هذا التخصص .
- 8- بحسب تخصصك نرجو منك الدخول الى موقع الجامعة و على برنامج الملتحق به وتكوين صورة اولية عن الاساتذة في البرنامج من حيث التخصص والدرجة العلمية (ماجستير او دكتوراة) وما هو الاساتذة المفضل لديك.

وتفضلوا بقبول فائق الاحترام

Appendix 7: Camera Raw data

Participant No.	ANGER	CONTEMPT	DISGUST	FEAR	JOY	SADNESS	SURPRISE
1	9118	612	39	0	1215	125	11
2	651	627	142	3	2061	0	431
3	2973	2504	8	0	810	471	3
4	90	2746	915	131	250	761	746
5	1396	5168	9	0	416	8	57
6	1714	1061	17	0	176	315	0
7	3170	363	400	433	669	3	107
8	2149	485	533	0	396	87	153
9	4864	207	75	0	64	13	20
10	1112	146	674	10	400	26	241
11	2840	938	108	11	478	20	135
12	2463	369	204	8	174	347	257
13	887	421	548	106	137	3311	145
14	882	1332	175	14	581	15	77
15	1795	450	11	24	73	1	17
16	508	1597	21	792	197	918	202
17	1727	252	38	2	34	1449	3
18	1105	935	45	67	71	157	217
19	1121	254	178	0	226	17	96
20	1336	45	678	0	83	2	166
21	166	1150	111	652	332	341	492
22	14	152	0	712	985	1053	826
23	1552	422	59	119	1465	76	250
24	7	319	167	91	1638	4	48
25	239	209	6566	0	1162	10	333
26	3785	701	21	16	59	315	2306
27	1436	632	970	355	2986	0	100
28	3580	2382	1154	67	562	13	537
29	2289	701	4702	1	3934	718	207
30	11	1151	641	0	1124	907	1143
31	3458	1333	2754	22	870	1	6
32	602	1413	55	1860	1298	2140	188
33	1900	3847	485	28	4979	90	369
34	4824	97	366	32	496	0	2198
35	2770	1226	1710	1	918	306	334
36	5272	1269	529	239	789	2	7508
37	1	461	927	17	3635	6	4731
38	10322	1790	658	7	1425	10	43
39	2111	6056	2	683	3226	133	6021
40	654	1087	554	227	7867	77	1900
41	3430	8531	1734	297	4891	117	1311
42	6	275	0	299	1569	11885	381

Participant No.	ANGER	CONTEMPT	DISGUST	FEAR	JOY	SADNESS	SURPRISE
43	21250	964	18	45	140	78	9
44	10706	528	289	4	1139	34	678
45	375	679	1	4069	2120	2643	496
46	5627	422	7	17	252	123	2677
47	2913	727	34	43	3486	51	787
48	4525	338	2	15	5991	72	1
49	6	1684	110	783	3199	2304	2252
50	6	1684	110	783	3199	2304	2252
51	9565	370	351	20	131	17	175
52	17	439	152	888	6102	81	722
53	2937	272	1	764	2880	761	454
54	118	373	276	79	7857	19	124
55	1618	1423	465	49	1462	9	580
56	3146	873	51	136	494	1415	50
57	37	2341	46	10	241	2525	960
58	5795	92	120	1	945	6	18
59	4270	174	49	0	2174	38	6
60	314	5026	311	348	593	6	31
61	224	2880	75	2	76	1988	330
62	1355	1238	433	22	2665	262	667
63	168	2411	5	303	904	3379	35
64	3031	2271	9	314	441	984	757
65	355	4356	410	1665	131	954	173
66	33	831	30	264	739	2417	92
67	4224	1169	1102	2	46	43	69
68	2021	2454	25	22	19	31	85
69	155	2156	95	228	96	948	7
70	389	1026	37	80	11	31	268

Appendix 8: Converted camera data to Likert scale

Participant No.	ANGER	CONTEMP	DISGUST	FEAR	JOY	SADNESS	SURPRISE
1	1	3	4	4	4	3	5
2	4	3	3	4	4	5	2
3	2	1	5	4	3	2	5
4	5	1	1	2	2	2	2
5	3	1	5	4	3	4	4
6	3	2	4	4	2	2	5
7	2	4	2	1	3	5	4
8	2	3	2	4	3	3	3
9	1	5	3	4	1	4	4
10	4	5	1	3	3	3	3
11	2	3	3	3	3	4	3
12	2	4	2	3	2	2	3
13	4	4	2	2	2	1	3
14	4	2	3	3	3	4	4
15	3	4	4	3	1	5	4
16	4	2	4	1	2	1	3
17	3	4	4	4	1	1	5
18	4	3	4	2	1	2	3
19	3	4	2	4	2	4	4
20	3	5	1	4	2	5	3
21	5	2	3	1	3	2	2
22	5	5	5	1	4	1	1
23	3	4	3	2	4	3	3
24	5	4	3	2	4	5	4
25	5	5	1	4	4	4	2
26	1	3	4	3	1	2	1
27	3	3	1	1	4	5	4
28	1	1	1	2	3	4	2
29	2	3	1	4	4	2	3
30	5	2	1	4	4	1	1
31	2	2	1	3	3	5	5
32	4	2	3	1	4	1	3
33	3	1	2	3	4	3	2
34	1	5	2	3	3	5	1
35	2	2	1	4	4	2	2
36	1	2	2	2	3	5	1
37	5	4	1	3	4	4	1
38	1	2	1	4	4	4	4
39	2	1	5	1	4	2	1

Participant No.	ANGER	CONTEMPT	DISGUST	FEAR	JOY	SADNESS	SURPRISE
41	2	1	1	2	4	3	1
42	5	4	5	2	4	1	2
43	1	3	4	3	2	3	5
44	1	3	2	4	4	3	2
45	4	3	5	1	4	1	2
46	1	4	5	3	2	3	1
47	2	3	4	3	4	3	2
48	1	4	5	3	4	3	5
49	5	2	3	1	4	1	1
50	5	2	3	1	4	1	1
51	1	4	2	3	2	4	3
52	5	4	3	1	4	3	2
53	2	4	5	1	4	2	2
54	5	4	2	2	4	4	4
55	3	2	2	2	4	4	2
56	2	3	4	2	3	1	4
57	5	1	4	3	2	1	1
58	1	5	3	4	4	4	4
59	1	5	4	4	4	3	5
60	4	1	2	2	3	4	4
61	5	1	3	4	2	1	3
62	3	2	2	3	4	2	2
63	5	1	5	2	4	1	4
64	2	1	5	2	3	1	2
65	4	1	2	1	2	1	3
66	5	3	4	2	3	1	4
67	1	2	1	4	1	3	4
68	3	1	4	3	1	3	4
69	5	2	3	2	2	1	5
70	4	3	4	2	1	3	3

Appendix 9: Questionnaire Data

Participant No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	4	4	3	3	4	2	2	2	1	3
2	5	5	5	1	5	1	3	1	1	4
3	3	4	5	2	5	3	2	4	2	4
4	4	3	3	3	4	3	3	2	4	3
5	2	4	4	4	2	2	1	2	5	1
6	4	3	3	3	4	3	3	2	2	4
7	5	5	5	1	4	3	3	3	1	3
8	5	4	5	4	5	1	5	1	1	3
9	2	1	3	5	4	5	1	5	3	2
10	2	2	3	3	4	5	5	1	4	2
11	3	4	3	5	1	1	3	4	5	3
12	5	4	5	4	5	3	5	5	3	2
13	3	1	2	3	2	1	1	4	3	4
14	2	3	2	4	2	2	2	3	1	3
15	5	5	1	3	1	5	1	4	2	1
16	5	3	4	3	3	2	3	4	1	3
17	5	5	5	3	5	5	4	1	1	5
18	5	5	5	3	5	1	5	2	1	5
19	1	1	3	4	2	4	1	5	5	3
20	5	5	4	2	1	1	1	3	3	3
21	2	2	2	4	3	3	1	4	4	1
22	1	2	2	5	3	3	2	5	4	3
23	4	4	4	4	4	2	2	2	2	2
24	4	4	3	4	4	2	4	2	2	4
25	3	3	4	5	1	5	1	5	5	3
26	4	5	4	2	4	1	3	3	1	4
27	3	1	1	5	3	1	2	1	4	2
28	5	5	4	3	5	1	5	1	1	4
29	3	4	3	4	3	2	4	1	2	3
30	1	2	1	3	1	5	2	3	4	1
31	4	5	5	5	4	5	4	5	1	4
32	4	2	2	5	4	2	2	2	4	1
33	3	5	4	3	4	1	4	2	2	3
34	1	1	2	5	2	4	1	5	5	2
35	4	4	3	5	4	1	3	2	2	4
36	4	2	5	4	4	1	3	2	2	2
37	2	2	3	3	4	2	3	1	3	2
38	5	5	5	4	4	1	4	3	4	4
39	4	3	4	3	3	2	4	1	2	3
40	3	3	2	4	1	1	1	3	2	2
41	3	4	4	2	4	1	5	3	1	4

Participant No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
42	4	4	3	4	5	1	3	2	1	5
43	3	3	3	2	4	3	3	3	1	4
44	4	4	4	4	4	2	4	4	2	3
45	4	4	4	1	4	1	4	2	2	4
46	5	5	4	2	5	1	4	1	2	5
47	4	3	5	2	4	3	4	2	1	4
48	2	4	4	2	5	2	5	4	2	5
49	5	5	5	5	5	1	5	5	1	5
50	4	3	3	2	4	2	4	2	1	3
51	4	3	5	3	4	1	5	1	1	2
52	4	5	3	4	2	4	2	4	3	5
53	4	3	4	2	3	1	3	2	2	5
54	4	3	4	3	4	1	3	3	1	3
55	3	5	3	2	4	2	3	2	2	4
56	4	4	5	2	5	2	5	2	1	5
57	3	2	1	3	2	5	1	3	4	2
58	4	5	3	3	5	2	4	4	2	4
59	2	2	2	3	2	3	2	3	3	4
60	5	4	5	4	4	2	4	2	1	3
61	2	2	2	3	3	3	3	3	3	4
62	5	5	5	3	5	1	5	1	1	5
63	4	3	4	3	4	1	4	2	1	5
64	5	4	4	1	1	5	5	1	1	1
65	4	3	4	1	3	2	4	1	2	4
66	5	5	5	1	4	1	4	1	1	5
67	5	3	4	3	5	1	5	4	1	5
68	4	3	4	3	4	2	4	4	2	4
69	3	3	4	2	4	3	4	3	2	2
70	5	5	5	4	5	1	4	4	1	5

Appendix 10: Personal Data for participants

Participant No.	Gender	Academic_level	Teaching_or_study	Comp_time	Non_windows_sys	Internet_user	Internet_usage_time	Internet_usage_sites
1	1	2	4	3	1	4	8	5
2	1	2	4	1	1	4	8	5
3	1	2	4	1	2	4	8	5
4	2	2	4	1	2	4	8	5
5	1	2	3	1	2	4	8	5
6	1	2	4	2	2	4	8	5
7	1	1	3	2	1	2	8	6
8	1	1	3	4	1	4	8	5
9	1	1	3	1	1	4	8	1
10	2	1	3	1	1	4	8	1
11	1	1	3	3	2	4	8	1
12	1	1	3	3	1	3	4	5
13	2	1	3	2	1	4	8	5
14	2	1	3	1	2	4	8	5
15	1	1	4	2	2	4	8	5
16	2	1	4	2	2	4	8	1
17	2	1	4	3	1	4	8	1
18	2	1	3	2	2	4	8	5
19	1	1	4	1	2	4	8	5
20	1	1	4	3	2	4	6	5
21	2	1	4	1	1	4	8	5
22	2	1	3	1	1	4	8	1
23	2	2	4	1	1	4	8	5
24	2	1	4	1	2	4	8	5
25	1	1	4	1	2	4	8	5
26	1	1	4	2	1	4	8	5
27	2	1	3	1	1	4	8	5
28	2	1	3	2	2	4	8	5
29	2	2	4	2	1	4	8	5
30	1	2	4	1	1	4	8	5
31	1	2	4	2	2	4	8	5
32	2	2	4	2	1	4	8	5
33	1	2	4	2	2	4	8	5
34	2	2	4	1	2	4	8	5
35	2	2	4	2	1	4	8	5
36	2	1	2	4	1	4	8	1
37	2	1	4	3	1	4	7	1
38	1	1	4	2	1	4	8	5
39	1	1	4	1	2	4	8	5

Participant No.	Gender	Academic_level	Teaching_or_study	Comp_time	Non_windows_sys	Internet_user	Internet_usage_time	Internet_usage_sites
40	1	1	3	3	2	4	8	1
41	2	1	3	2	2	4	8	5
42	2	1	3	3	1	4	8	1
43	1	1	3	3	1	4	8	1
44	1	1	4	2	1	4	8	5
45	2	1	3	2	1	4	8	5
46	1	1	4	2	1	4	8	5
47	1	1	4	1	1	4	8	5
48	1	1	3	2	2	4	8	5
49	1	1	4	2	1	4	8	5
50	1	1	4	1	2	4	8	5
51	1	1	4	2	1	4	8	5
52	1	1	4	4	1	4	8	1
53	1	1	4	2	1	4	8	5
54	2	1	4	3	1	4	8	5
55	1	1	4	1	1	4	8	5
56	1	1	3	4	2	4	8	1
57	1	1	3	2	1	3	8	5
58	1	1	4	3	1	4	8	1
59	1	1	3	4	2	4	8	5
60	1	1	4	1	1	4	8	1
61	1	1	4	1	1	4	8	5
62	2	1	2	2	1	4	8	5
63	1	1	3	2	1	3	8	5
64	1	1	4	3	1	4	8	5
65	1	1	4	2	2	4	8	5
66	2	1	4	2	1	4	8	5
67	1	1	4	2	2	4	8	2
68	1	1	4	2	2	4	8	5
69	1	1	4	3	2	4	8	1
70	2	1	4	1	2	4	8	5

Appendix 11: Usability Data

Participant No.	QUESTIONNAIRE USABILITY SCORE	CAMERA USABILITY SCORE	QUESTIONNAIRE USABILITY SCORE GRADE	CAMERA USABILITY SCORE GRADE	CAMERA	QUESTIONNAIRE
1	38	46.41	F	F	ok	poor
2	40	42.84	F	F	ok	ok
3	53	46.41	F	D	ok	good
4	60	64.26	C	D	good	good
5	63	39.27	F	D	ok	good
6	53	39.27	F	D	ok	good
7	60	49.98	F	D	ok	good
8	73	53.55	D	C	good	good
9	43	32.13	F	F	poor	ok
10	58	46.41	F	D	ok	good
11	58	49.98	F	D	ok	good
12	48	53.55	D	F	good	ok
13	60	53.55	D	D	good	good
14	53	42.84	F	D	ok	good
15	38	24.99	F	F	worst	poor
16	50	57.12	D	F	good	ok
17	50	32.13	F	F	poor	ok
18	35	42.84	F	F	ok	poor
19	40	35.7	F	F	poor	ok
20	50	35.7	F	F	poor	ok
21	70	60.69	D	C	good	good
22	63	53.55	D	D	good	good
23	58	53.55	D	D	good	good
24	53	35.7	F	D	poor	good
25	53	42.84	F	D	ok	good
26	53	57.12	D	D	good	good
27	70	57.12	D	C	good	good
28	65	74.97	B	C	excellen	good
29	60	64.26	C	D	good	good
30	60	67.83	C	D	good	good
31	53	49.98	F	D	ok	good
32	53	67.83	C	D	good	good
33	55	67.83	C	D	good	good
34	68	53.55	D	C	good	good
35	68	71.4	C	C	good	good

Participant No.	QUESTIONNAIRE USABILITY SCORE	CAMERA USABILITY SCORE	QUESTIONNAIRE USABILITY SCORE GRADE	CAMERA USABILITY SCORE GRADE	CAMERA	QUESTIONNAIRE
36	63	67.83	C	D	good	good
37	60	53.55	D	D	good	good
38	53	60.69	D	D	good	good
39	65	74.97	B	C	excellen	good
40	63	71.4	C	D	good	good
41	63	82.11	A	D	excellen	good
42	38	49.98	F	F	ok	poor
43	50	42.84	F	F	ok	ok
44	58	64.26	C	D	good	good
45	60	60.69	D	D	good	good
46	60	49.98	F	D	ok	good
47	45	57.12	D	F	good	ok
48	45	42.84	F	F	ok	ok
49	60	71.4	C	D	good	good
50	60	71.4	C	D	good	good
51	48	49.98	F	F	ok	ok
52	53	53.55	D	D	good	good
53	53	60.69	D	D	good	good
54	63	42.84	F	D	ok	good
55	63	64.26	C	D	good	good
56	50	57.12	D	F	good	ok
57	50	57.12	D	F	good	ok
58	60	42.84	F	D	ok	good
59	58	39.27	F	D	ok	good
60	65	53.55	D	C	good	good
61	58	49.98	F	D	ok	good
62	60	67.83	C	D	good	good
63	65	53.55	D	C	good	good
64	65	67.83	C	C	good	good
65	63	67.83	C	D	good	good
66	55	46.41	F	D	ok	good
67	70	53.55	D	C	good	good
68	40	42.84	F	F	ok	ok
69	58	46.41	F	D	ok	good
70	50	39.27	F	F	ok	ok

Appendix 12: Summary of the Personal Description of Participants and Showing the Computer and Internet Skills of them

Group	Number of Participants	Participants majors	Personal description	Computer skills	Internet skills
Master Students	14	Computer Science :6 MBA/ Entrepreneurial:7 Public Health :1	Age:24-52 Language : Arabic Education :currently study or finish master degree Gender : 8male and 6 female English : good to excellent	Uses computer : more than 92% Skills: medium (50 %of participants use computer 8hour daily and 50 % uses non – windows operating systems)	Uses internet : Excellent (100% Use internet Daily) Skills : Excellent (100% uses all sites types and more than three years)
Bachelors students	56	Business and Economics:4 Computer Science :3 Health Profession :25 Human Rights and International Law:6 Media and T.V:12 Medicine:3 Pharmacy:1 Political Science :1 Social Work :1	Age:18-35 Language : Arabic Education :currently study or finished Gender : 36male and 20 female English : medium to very good	Uses computer : more than 57% Skills : below medium (more than 41 %use computer more than 4 hour daily and 40% use non –windows operating systems)	Uses internet : Excellent (more than 92% Use internet daily Skill : good to Excellent (more than 67%uses all sites types and more than 94% uses internet more than 3 years)

Appendix 13: Figures show Demographic Data about participant in experiment

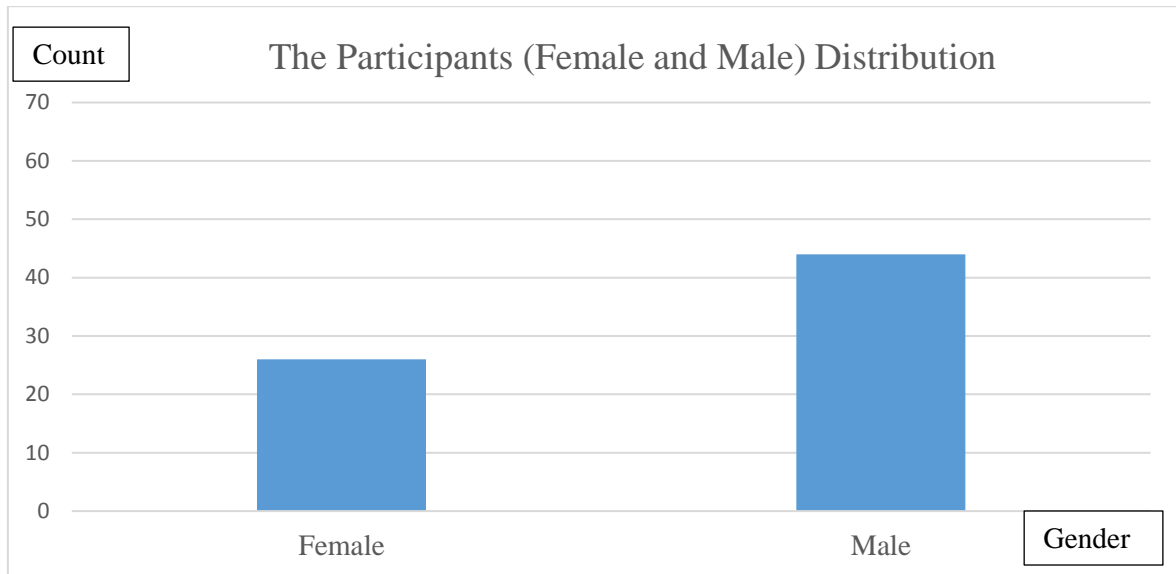


Figure (5-27): The Count of Male and Female (56 Male and 14 Female)

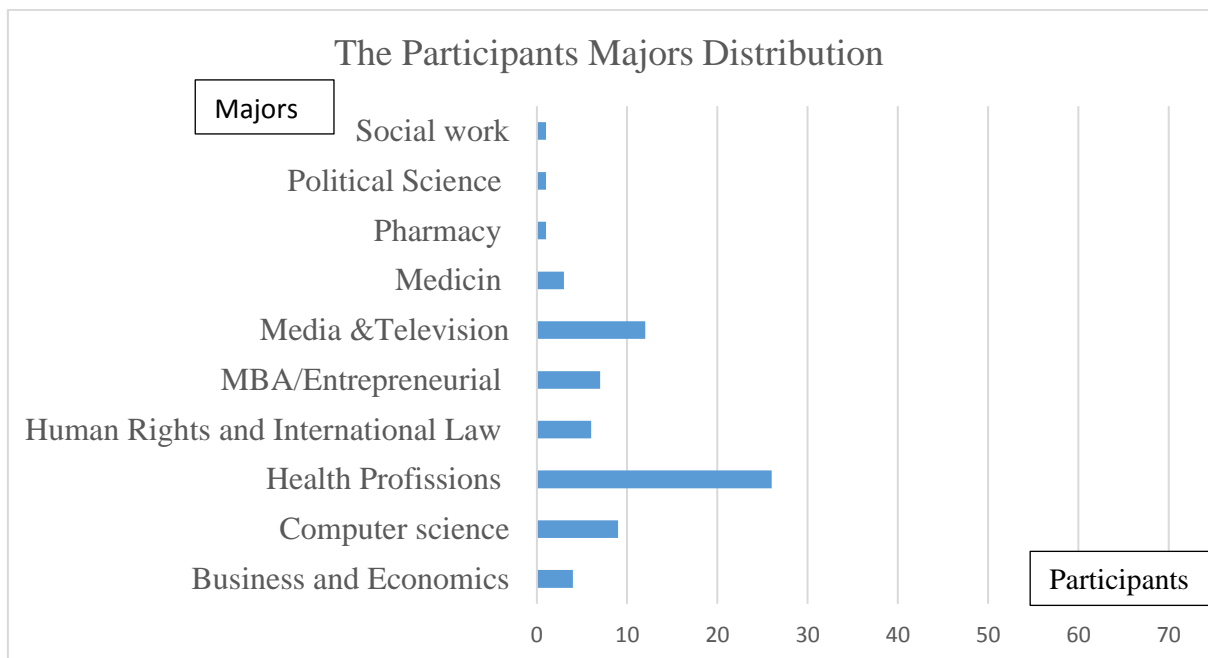


Figure (5-28): The Participants Majors Distribution

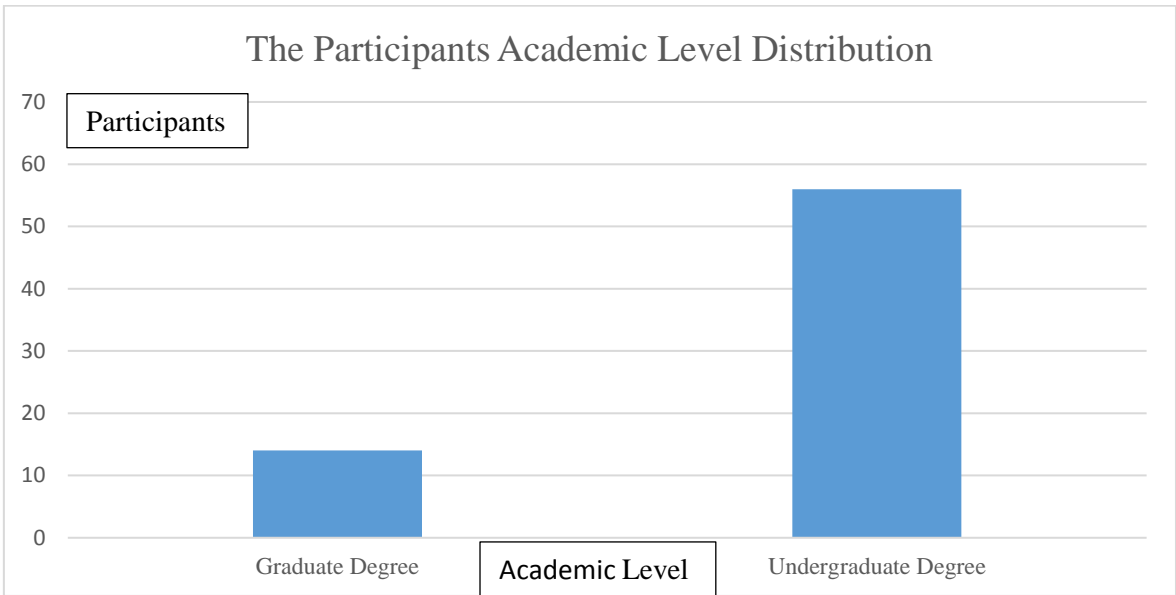


Figure (5-29): The Participants (Academic Level) Distribution

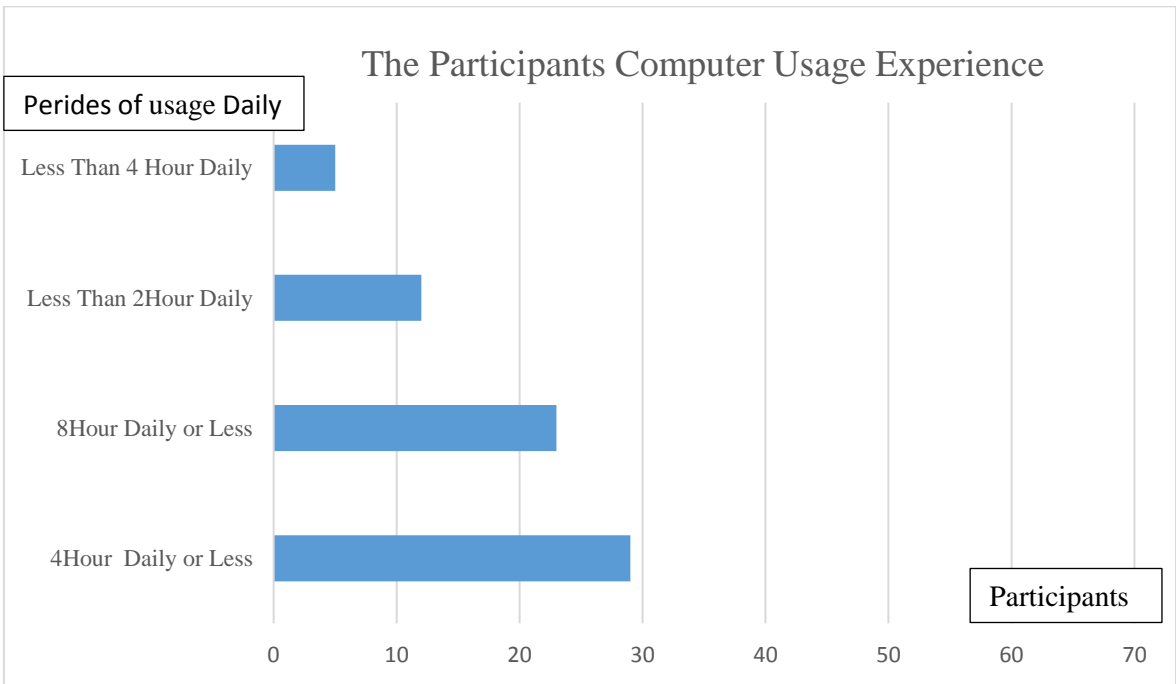


Figure (5-30): The Participants Computer Usage Experience

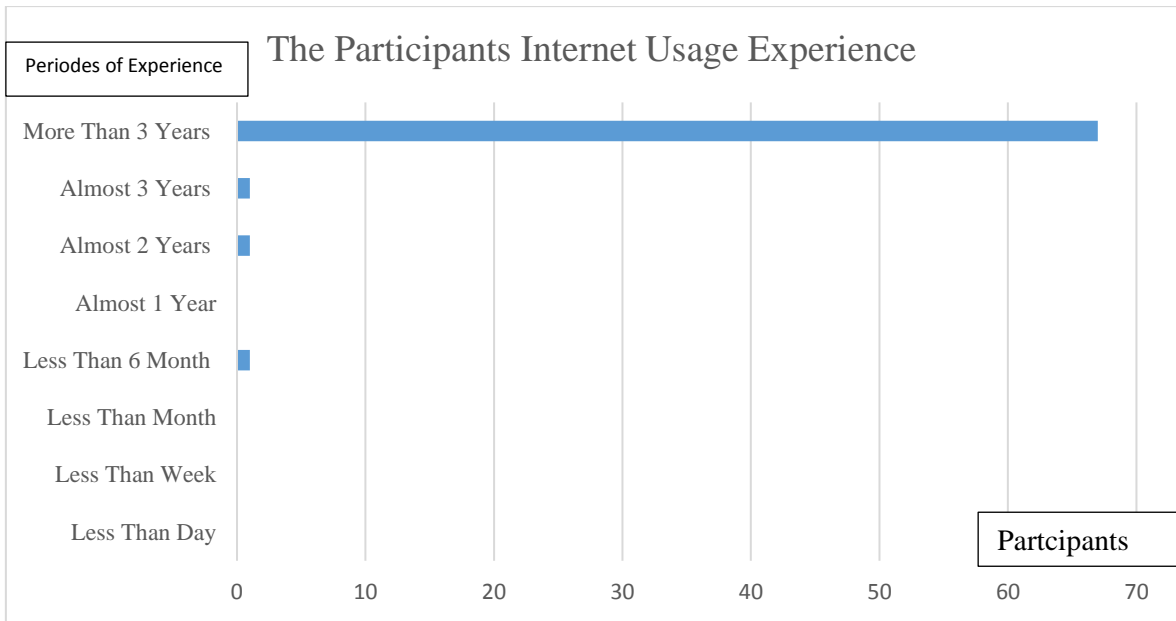


Figure (5-31): The Participants Internet Usage Experience

Appendix 14: The task forms in English

Form1

The participants will be asked to use the Website of Al-Quds University for performing the following tasks:

- 1- The participant will be asked to explore the Website of Al-Quds University, to get the last publication of a specific professor, the participant will use the Arabic and English versions of website to get information in Arabic and English.
- 2- The second task that participant will do, is to get information about master degree courses description for a specific sector, Arabic and English versions of university website.
- 3- The third task the participant will be asked to search the university library website, to get information about thesis with specific topic, using two versions of website of Arabic and English.

Form2

The Participants will be asked to use the Website of Al-Quds University for performing the following tasks :

- 1- The participant will be asked to explore the Website of Al-Quds University, to get information about the role played by Al-Quds University over participant academic specialization (Entrepreneurial) to enhance situations of the Palestinian organizations by activities ,workshops, engagements with government and nongovernment organizations , offered new academic courses and graduation projects.
- 2- The second task that participant will do ,is to get information about objectives of your academic program , offered courses , grades , achieved courses and total achieved credit hours.
- 3- The participant will be asked to write two or three short sentences describing thesis idea (if the participant choose thesis track not comprehensive exam) and will be instruct to use the Website of Al-Quds University to find professor

closest to the idea that he or she choose .The participant describing will be include professor name , specialization and research interests.

Form 3

The Participants will be asked to use the Website of Al-Quds University for performing the following tasks :

- 1- The participant will be asked to explore the Website of Al-Quds University, and get information about programs like: Science, Engineering and Health professions.
- 2- The participant will be asked to explore the Al-Quds Website and get information about the number (male and female) of professors or instructors in your program or faculty.
- 3- The participant will be instruct to enter E-class of Al-Quds Website and view syllabus for one of offered courses.
- 4- The participant will be asked to enter his or her portal of Al-Quds Website and view his or her course schedule.
- 5- The participant will be asked to explore the Al-Quds University Website and find the important activities that student doing.
- 6- The participant will asked to explore the Al-Quds University Website and find last four news about Al-Quds University. The participant will be mention the dates ,types and university relationship to these four news .
- 7- The participant will be asked to instruct new student want to enroll medical laboratory using Al-Quds Website. He or she will provide new student with information like : the nature of medical laboratory ,requirement ,the number of teachers and the faculty of this program.
- 8- The participant will be asked to explore the Al-Quds Website and get information about favorite professors or instructors in your program or faculty. Information must include academic degree and specialization.

Appendix 15: The Sessions of Experiment in al-Quds University Main Campus in Abu-dies

Participant No.	Date	Place	Time	Duration
31	29/11/2015	Al-Quds University Main Campus - Abu-dies	11:19:36 AM	0:07:44
32	29/11/2015	Al-Quds University Main Campus - Abu-dies	3:00:17 PM	0:09:30
33	27/7/2016	Al-Quds Open University -Qalqilya Branch	1:23:12PM	0:24:10
34	18/10/2016	Al-Quds University Main Campus - Abu-dies	2:35:06PM	0:23:23
35	28/7/2016	Al-Quds University Main Campus - Abu-dies	6:06:38PM	0:20:47
36	28/7/2016	Al-Quds University Main Campus - Abu-dies	6:33:07PM	0:21:26
37	11/10/2016	Al-Quds University Main Campus - Abu-dies	8:19:14AM	0:17:06
38	11/10/2016	Al-Quds University Main Campus - Abu-dies	9:10:33AM	0:24:46
39	11/10/2016	Al-Quds University Main Campus - Abu-dies	12:01:40PM	0: 38:09
40	12/10/2016	Al-Quds University Main Campus - Abu-dies	10:10:40AM	0:35:30
41	12/10/2016	Al-Quds University Main Campus - Abu-dies	11:05:32AM	0:22:33
42	12/10/2016	Al-Quds University Main Campus - Abu-dies	12:28:11PM	0:17:08
43	12/10/2016	Al-Quds University Main Campus - Abu-dies	1:55:17PM	0:31:19
44	12/10/2016	Al-Quds University Main Campus - Abu-dies	4:05:51PM	0:28:28
45	16/10/2016	Al-Quds University Main Campus - Abu-dies	9:11:01AM	0:24:01
46	16/10/2016	Al-Quds University Main Campus - Abu-dies	10:55:49AM	0:21:23
47	16/10/2016	Al-Quds University Main Campus - Abu-dies	1:19:04PM	0:16:19
48	16/10/2016	Al-Quds University Main Campus - Abu-dies	1:51:21PM	0:26:28
49	16/10/2016	Al-Quds University Main Campus - Abu-dies	3:38:25PM	0:33:06
50	16/10/2016	Al-Quds University Main Campus - Abu-dies	4:55:30PM	0:21:44
51	16/10/2016	Al-Quds University Main Campus - Abu-dies	5:44:20PM	0:39:24

52	18/10/2016	Al-Quds University Main Campus - Abu-dies	1:18:05PM	0:19:45
Participant No.	Date	Place	Time	Duration
53	18/10/2016	Al-Quds University Main Campus - Abu-dies	2:02:58PM	0:29:40
54	18/10/2016	Al-Quds University Main Campus - Abu-dies	3:20:25PM	0:20:01
55	18/10/2016	Al-Quds University Main Campus - Abu-dies	3:59:10PM	0:36:16
56	19/10/2016	Al-Quds University Main Campus - Abu-dies	8:40:33AM	0:19:22
57	19/10/2016	Al-Quds University Main Campus - Abu-dies	9:30:07AM	0:30:50
58	19/10/2016	Al-Quds University Main Campus - Abu-dies	10:08:50AM	0:26:36
59	19/10/2016	Al-Quds University Main Campus - Abu-dies	10:59:20AM	0:21:02
60	19/10/2016	Al-Quds University Main Campus - Abu-dies	12:40:55PM	0:34:01
61	19/10/2016	Al-Quds University Main Campus - Abu-dies	1:52:50PM	0:18:44
62	19/10/2016	Al-Quds University Main Campus - Abu-dies	3:20:14PM	0:23:35
63	23/10/2016	Al-Quds University Main Campus - Abu-dies	9:05:42AM	0:27:47
64	23/10/2016	Al-Quds University Main Campus - Abu-dies	9:49:24AM	0:21:05
65	23/10/2016	Al-Quds University Main Campus - Abu-dies	10:18:19:AM	0:19:22
66	23/10/216	Al-Quds University Main Campus - Abu-dies	11:12:05AM	0:19:32
67	23/10/2016	Al-Quds University Main Campus - Abu-dies	12:05:50PM	0:35:41
68	23/10/2016	Al-Quds University Main Campus - Abu-dies	12:58:10PM	0:26:21
69	23/10/2016	Al-Quds University Main Campus - Abu-dies	2:36:55PM	0:29:35
70	23/10/2016	Al-Quds University Main Campus - Abu-dies	4:20:32PM	0:21:11