ACKNOWLEDGEMENT

TABLE OF CONTENTS

1. SUMMARY

The project topic "Collaborative Touchless Interaction" is an interesting and vast topic which consists of various aspect/fields, in particular the Human Computer Interaction subject area, of Computer Science. With the rapid development in computer technology and related fields computer systems are used in most aspects of human day-to-day activities. This has led to the change in our perspective towards computer systems and human interaction with these systems.

This report gives an insight of the background study related to Human computer Interaction, Touchless Interaction, Exertion Interface & games, Collaborative Play in Urban Screen Games which are so far independently implemented. This project covers the various important aspect of human life such as exertion activity, social interaction and play, games in public environment.

The main objective of this project is to design and develop an Exertion game based on Collaborative Touchless Interaction which is played in a public space (ideally an open arena) on a large public display system. In this project about 60% of the major work is research; hence it involves a lot of reviewing of the existing framework and design, giving a critical analysis on whether it fits our system requirement. The remaining 35% in implementation of the game and other 5% would be any theoretical suggestions made during the research and implementation stage.

The conclusion drawn from this research was used to implement a Human pong game which would try to bring in an exertion activity such as running, jumping with collaborative touchless interaction by the player with urban public screen, all on a single platform of a game played in public. The aim of this project is to develop an exertion game for a public setting with touchless interaction based on Mueller's framework and to check if this framework can be used to develop more such exertion game that come under the category of social game or suggest changes to existing framework or build a new one. The game was successfully designed & implemented based on Mueller's framework. An experiment was conducted to test the game in a real environment and feedback from the participants was taken in form of questionnaire and interview.

Based on the design & implementation, results of the experiment based on participants' feedback it can be concluded that the present state of Mueller framework befits the game/system we are intending to research, i.e. a computer game, with high level exertion required to play the game, for large screens in urban setting having touchless interaction with those screens.

2. INTRODUCTION

2.1 Objectives

The main objective of this project is to design and develop an Exertion game based on Collaborative Touchless Interaction which is played in a public space (ideally an open arena) on a public display system. Going forward with the design and implementation, we would identify the issues when trying to conglomerate three uniquely different fields such as Exertion Games, Touchless Interaction and public/large display system of Computer Science on a single platform (game) and attempt to provide a solution to those issues.

2.2 Motivation

Video games, that provide interactive user interface and gives visual feedback, are most popular among people and children alike and children find the games fun and entertaining. These days, people are more inclined towards video games and spend most of their time in playing these sedentary games than a traditional outdoor sport. This gives a negative impact on the health and lifestyle of humans, making them lethargic, obese and also isolating them from the outside world in terms of socialising and physical activity, making them sedentary in their world of video games.

In order to overcome or minimize the adverse effects of video games and yet provide the entertainment, more pervasive and intuitive game console has to be developed. Hence, an attempt was made to design and develop a touch less interaction game which can act as a source of physical workout along with the necessary entertainment. Playing touchless interaction games requires significantly more energy than their real counterparts that they simulate. Hence these games are better than the sedentary video games in terms of energy expenditure and physical activity. Apart from the physical activity, touchless and controller free interactive gaming is more enjoyable and requires more effort than playing games by clicking buttons. Greater involvement and participation of players is required while playing controller free games, which gets the family members off the couch and strengthen the bond in the family or socially bind people when played in a public space, through the interactive, energetic and fun filled type of playing games.

With the touchless interactive game in mind, developing the game fulfilling all the requirements by taking care of all the nuances of the game and niches of players is quite challenging. Efforts were put in developing the game to provide an interactive and interesting game, different from other video games and apparently healthier game helping people to come out of their stagnant life.

2.3 Aims

In my thesis I study Muller's framework for exertion game by implementing game in a public setting, and analysis if game with physical activity provide a sense of exertion and helps kick start a great conversation between strangers using the large screens in the urban setting. The main aim of such design is giving participants an experience of exertion presenting a situation for social exercising/gaming and investigating if that facilitates unknown people in a public setting to interact with each other. By exertion activity I mean, the one that requires intense physical effort like running, hogging or playing a sport.

This whole setting of exertion activity in a public setting and interaction in a touchless manner with large screens raises a lot of questions and also provide great opportunities for developing system with social exercising as a genre. These questions ought to be considered only as a part of the various questions that could be the part of the study.

- ❖ What level of social interactions does an exertion game facilitate in a public setting?
- ❖ Do exertion games support the feel of drawing people together? Does it provide a sense of experiencing a feeling of exercising together?
- ❖ Does an exertion game alleviate starting a conversation between strangers?
- ❖ Do exertion games help getting to know a person better by conveying further information about a person, which traditional button-press games cannot?
- ❖ Does exertion game provide an essence of competition or collaborative playing, or both to an extent, in a public setting?
- ❖ What are the advantages of touchless interaction in comparison to traditional touch based interactions?
- ❖ How can the large screens in public space used for social gaming?
- ❖ How can we incorporate touchless interaction with large screens in public space?
- ❖ How does the interaction with an Exertion game in a public setting be different from those in non-public setting?
- ❖ How could we implement exertion games in a touchless manner?
- ❖ Is Touchless exertion game enjoyable to play?

2.4 Scope

This thesis reviews the experience of participants playing an exertion game in public setting. The participants were grouped into team of two. Due to the limitation in space and hardware, it was not very feasible to conduct the experiment on large teams. However recommendations were provided to develop games that support large teams and rating & feedback can be changed based on it.

2.5 Thesis Statement

I postulate that an exertion game played in public setting involving touchless interaction will not only help people to easily acquaint with each other but also provide a great experience of social gaming with a sense of exertion making it more fun compared to a traditional passively-interactive button-press computer games.

2.6 Thesis Overview

Chapter 1 provides a single page summary of the entire thesis. Chapter 2 provides a concise understanding of the social exertion gaming and ability for assisting interaction among unknown people in a public place. In this chapter the aim of the project and the thesis statement is articulated. In chapter 3 previous works in various related fields like HCI, touchless interaction, and content of large screens are reviewed and previous research made by Mueller in exertion game is discussed. I designed a game that uses an exertion activity like running which can be played in public space, which is described in chapter 4, beside the technical details of the implementations.

Chapter 5 illustrates the experiment combined with the experience of the participants. The increase in the interaction levels before and after gaming between the participants were examined. The results and observations obtained through interviews and questionnaire are pointed out in chapter 6. Chapter 7 concludes the discussion with suggestion for further improvements in the game.

2.7 Summary

This chapter suggests the importance of physical activities in today's world. Such activities when combined with technologies bring about a social bonding that encourages interaction among unknown people. It defines the motivation behind developing an exertion game for public setting and its related benefits in the current day scenario. It throws light upon the aim of the project which is based on Muller's framework and the scope of the project.

3.0 LITERATURE REVIEW & BACKGROUND STUDY

3.1 Introduction

An in-depth literature review was made on various topics such as Human-Computer Interaction (HCI), Touchless Interaction, Exertion games, Public space games, Public space large displays and on various approaches to design such systems. A crystallize understanding of all the above topics were acquired by reviewing a large number of publications. The significant aspects of touchless interaction in HCI are discussed in different publications thus assisting to figuring out the advantages and disadvantages technology. An exhaustive analysis was made on the systematic exertion games design for social play. An extensive research was made on the factor that affect the design of content and games for large public displays. Since the project is a research-oriented, during the initial background research stage I did not have exact cognisant as to what we are looking for the above subject areas of Computer Science and since most of these field are still in early research stage the information is in this literature review very generic.

Key research areas that were focused during this background study are.

- ➢ To explore existing design patterns of each area and analyse if this satisfies the projected system, if not think of solutions to suggest changes or develop a new design framework that befits the projected system.

- ➢ Research on the design and implementation factors in such collaborative environment and get a holistic critique view on such generic system.

- ➢ Difficulties in implementation of such games.

3.2 Human Computer Interaction (HCI)

The techniques used by humans to interact with a computer system or device is subjected to a lot of changes since the first era of computer system and this change will continue as the invention of new technologies. A generic definition Human-computer interaction is defined as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [1]. From a computer science viewpoint this not only intends to provide great calibre of interaction but also make interaction pleasurable with implementing intelligently adaptive active interfaces with multimodality design rather than passive interfaces with unimodal command or event/action based [2].HCI plays a vital role in the success for many reasons but the most basic of them is the fact that even the most advanced and efficient systems are ineffective unless they can be used in a simple and interactive manner by the user.

3.2.1 Subject areas of HCI
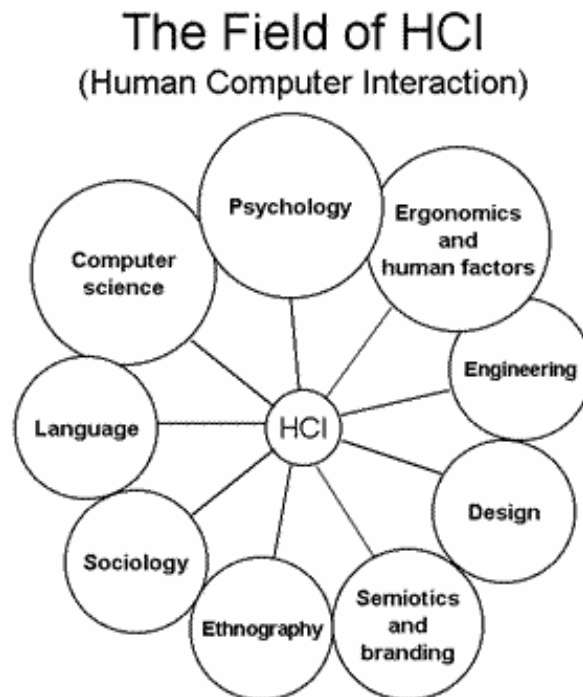
Figure 1

(Taken from Ref. [3])

Figure[1] gives the important fields associated with HCI such as , roots are from computer graphics, operating systems, ergonomics and human factors, engineering, cognitive psychology, and system aspect of computer science[3][4]. Among these various fields that are related with HCI, computer sciences and systems design plays a vital role as it calls for the designing, implementation and evaluation of interactive computer system/device based on the context in which the system will be used. Cognitive Psychology is the ability of the user in terms of perception, learning and reasoning. Ergonomics is all about a person's physical ability. Sociology is used to get a wider knowledge about context of the interaction.

3.2.2 Features of HCI

(N) The nature of HCI

> This provides viewpoints that give the nature of HCI and the environment it will be used. This perspective is about viewing HCI as communication between the system and the user.

The below diagram provides the five interconnected distinct features of HCI which are to be considered during HCI design [1].
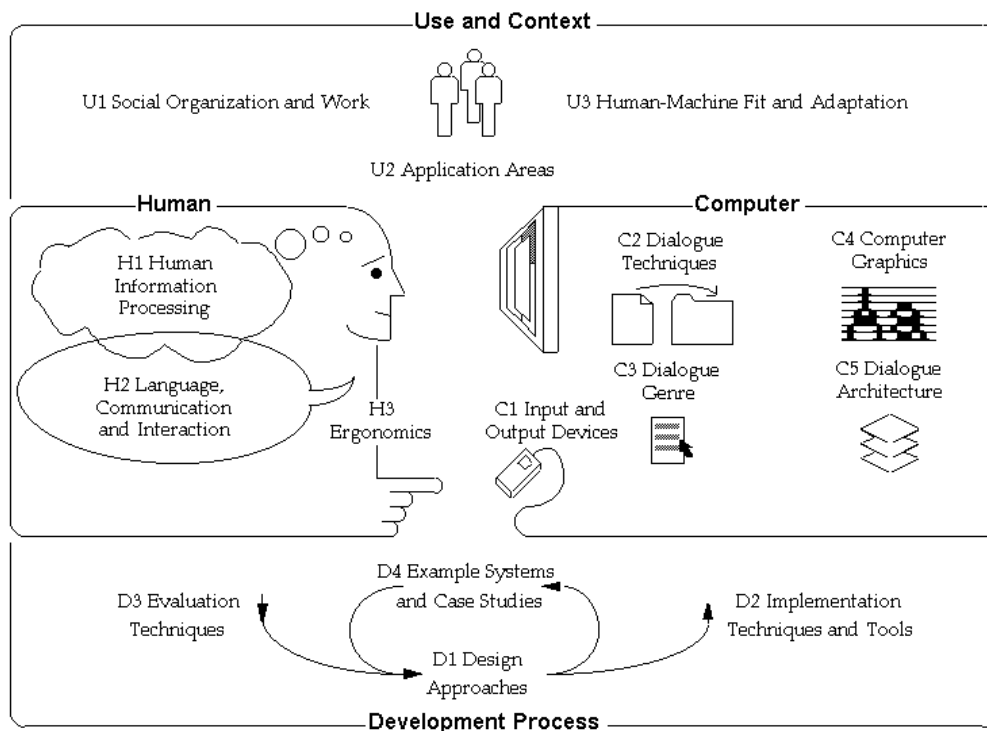
Figure 2

(Taken from Ref. [1])

(U) Use and context of Computers system/application

Computer systems are present in almost every aspect of people's life with greater use in social, organizational and work aspect of the user (U1). In this environment users access the various which are applications that are the part of the system (U2).In this feature the system designer must think of the human, technical, and use of the application and make sure all these aspects fit with each other (U3).

(H) Human (user) characteristics

During the design HCI, the human side aspects of information processing (H1) [4], human communication and interaction methods (H2), and physical features of system users (H3) have to be taken into account.

(C) Computer system and interface architecture

On the system side we need to focus on input and output device, technologies necessary for the system implementation and various technical architectures such as networking, multitasking that help in the implementation of the system to satisfy the requirements.

(D) The System Development process.

The system development process involves integrating human-computer interaction methods in the design of the system using the information from the about features (D1), then implement the design using the required technology and tools (D2), develop techniques for evaluating the implemented system (D3).

3.2.3 HCI Paradigms

HCI paradigms would include the following components [5]:

❖ Basic knowledge of the important features of interaction.

❖ Set of various types of answerable questions that related to about those features of interaction, the paradigm has knowledge about.

❖ Set of wide range of methods and procedures which can be implemented to give justifying solutions to the questions.

❖ Basic knowledge of how to interpret the outcomes of these methods.

3.2.3.1 The Three paradigms of HCI

➢ *The First Paradigm*

It is a combination of two diverse aspects, technology and human factors, resulting in interaction in a form of human-technology pairing. The focus of this paradigm, at that point was to provide consistent and simple interaction between humans and computer system. It mainly focused on identifying problems in the paring and providing practical solutions to those problems. In this paradigm the interaction is considered as a human-technology pairing [5].

➢ *The Second paradigm*

In this paradigm the focus completely shifted to the totally different view; it is about primal combination of human mind and computer as symmetric information processors [5].It focuses from both views, what's occurring in the computer system at the same time in the human mind. In this paradigm the information communication between the human and the computer is conceived as interaction. Primary focus is about precise and effective communication.

➢ *The Third paradigm*

The view considers the holistic perspectives of the system within which the core is "interaction as phenomenological situated" logic. The primary aim is to endorse for interaction of "situated action in the world" [5]. This includes dealing with the dubiousness that arises in the complex situations of the environment for which the system is designed. In this paradigm the main aspect is to basically understand the interaction with respect to the context of the system and to make it a part of the system information flow.

3.2.4 User Activity

During designing an application involving HCI, various characteristic of human behaviours and communication methods have to be considered. At most times, complexity involved with the human in interaction process with the technology is overshadowed by the easiness of the interaction method. Depending on the application's functionality, usability and the targeted audience, varies the complexity level of the application interfaces.

User activity can be broadly classified into three different levels: physical [6], cognitive [7], and affective [8].

1. Physical – this ascertain the dynamics/ bodily movements of user during interaction with computer system.

2. Cognitive – this view provides the ways by which the users can understand and interact with computer system.

3. Affective – this perspective is the latest and trending one, which concentrates on the providing a pleasurable interaction experience and also to impress the user by providing active interface for active interaction that enhances the user's engagement with the technology .This can be achieved by interactive system response to the user.

In this review we would focus more on physical and affective aspect of interaction .By combing the various methods of interaction and improving the performance of the method used, we can provide excellent and pleasurable interaction experience to the user.

3.2.5 HCI Systems Architecture

System configuration plays a vital role in many aspects system of design including HCI. The basics of the systems configuration that involves the HCI are the inputs and outputs methods. HCI system architecture provides snapshot of various these inputs and outputs method and how their collaborative work enhances the user interaction experience.

The HCI system can be broadly classified into

- Unimodal Systems
- Multimodal Systems

Uni-modal System

The different methods allow users to interact with computer system. This unique interaction methodology is called a modality [8].

Unimodal systems are developed based on only one modality. On the bases of the nature of these different modalities, they are categorised into three groups [8]:

1. Visual Based Modality
   This is the most widely used modality. It observes the visual response of the humans by tracking their facial expression, change in physical position of the body, gesture recognition eyes tracking and various other aspect of visual movements uses them as a input and output dynamics. Body movement tracking [2] and gesture recognition [11] [3] is mainly focused in this area and have been used to develop application with HCI event based scenario.

2. Audio Based Modality

   The audio/sound plays a vital role in the overall interaction experience when using a computer and also has important role in HCI systems. This modality involves acquiring signals from various audio sources and processing them to obtain information. Many technologies like speech and speaker Recognition, emotion analysis using audio and music for interaction have been developed. Speech and speaker recognition are the two primary technologies that have been widely used and researched.

3. Sensor Based Modality

   In this modality there exists atleast one physical sensor aiding the interaction between the user and computer system. These sensors can range from very simple to highly advanced ones. Various technologies build using this modal are from a traditional simple mouse, keyboard, pen based, joysticks and other gaming consoles to highly advance like pressure, temperature, smell sensor.

Multi-modal systems

As the name refers multi-modal, system developed using this modal implements various combination of the visual, audio and sensor modal. In the system with these modalities, refer to the ways in which the system captures the inputs and outputs the results. Consequently in a multimodal system there would be more than one interface that enables the human computer interaction through two or more styles of input and output unlike the traditional computer system that uses mouse and keyboard for input and a monitor for output. The accurate number of input and output modals, the technologies and the methodologies used for implementation varies from among multimodal system and is based on the requirements of the system .Most important aspect of developing system using multimodal architecture is to make sure that there is a perfect collaboration between different modalities used in the design [8].

3.3 Touchless Interaction

Touchless Interaction is about controlling/interacting with a Computer system or any device eliminating the encumbrance of physical contact with an interactive system. This results in a gratifying interaction experience. For example interacting with a device using a wireless controller is not considered as touchless Interaction.

3.3.1 Touchless Interaction Models

Touchless interaction can be multimodal interaction process which can include interaction based on
- The visual modality – change of position, form or colour,
- The auditory modality – based on speech recognition &sounds change or/and
- The olfactory modality - odours [13].

In the following project, we will be focusing/using visual modality [13], i.e. change in users form and position with respect to hand/body, as germane input to the touchless interaction system.

3.3.2 Classification of Gestures

 "A gesture is a motion of the body that contains information" [14].Cadoz and Mulder [14][15] classified hand movements based on their functionality or intend of use into *semiotic*, *ergotic*, and *epistemic.*

1. Semiotic as hand movements used to convey meaningful information or message.

2. Ergotic as those hand movements used to alter object present in the physical environment.

3. Epistemic as those hand movements used to gain knowledge of the surrounding with the sensation of touch (tactile haptic exploration property)[14].

We mainly focus on empty handed semiotic gestures that can be used for interaction with a device.

3.3.3 Interaction Styles

There are two major interaction styles that have to be considered when opting for touchless Interaction. They are Direct Manipulation and Indirect Manipulation [13].

3.3.3.1 Direct Manipulation

Direct manipulation corresponds to what is known as control in an engineering process, where changing a variable determine the control and the change in control is given back so that the variable to be re adjusted to get the desired change. Direct manipulation corresponds to a direct mapping between the semantic & syntactic level. The change is syntax should result in a semantic change the system level and these changes in the internal level should be made visible on the screen. From the Human gesture aspect the direct manipulation are made using ergotic or epistemic gestures. The interaction always tends to change some apprehensible state but not to convey a message.

3.3.3.2 Indirect Manipulation

Indirect Manipulation is diametrically different to its counterpart Direct manipulation, It is termed as *"communication based interaction"*.[13].Hence indirect manipulation or communication based interaction are associated with the gesture based interactions but direct manipulation interaction is based on non-gestures.

3.3.4 General Reasons for Touchless Interaction

1. Aseptic environments conditions: Touchless Interactions help preserving aseptic conditions of the surrounding, especially when used for interaction with computers (medical devices) in operation room and other sterilised environments. With use of Touchless interaction technology instead of touch-based helps in efficient utilization of resources [13].

2. Security of system: In the case of surveillance cameras or similar devices for sensing movements or other security can be placed in a secure place and interaction with such device can happen in a touchless manner [13].

3. Shared usage: Collectively used Interactive computer system can be easily accessed with touchless interaction by everyone and also help interacting with large displays like those in classroom or lecture theatre.

4. Touchless Interaction can be used for interaction with large screen placed at distance from the user by processing their hand gestures eliminating the constraints in physical touch based interactions, hence facilitating natural interaction with tangible information systems [16].

5. Touchless interaction can be used in application that requires three dimension perspectives. It is easy to interact with interfaces and object in such an environment using touchless interaction.[13]

6. Touchless interaction is the preferred interactive system even though it not easy to design a perfectly working and faster system compared to the traditional touch-based interaction because it provides a pleasurable and enjoyable interaction experience for the users.

3.4 Interaction in Public space & Social Interaction

Social interaction plays a vital role for eudaimonia of individuals. Nevertheless in a book "called Bowling Alone", the author describes that individuals (author refers American society) growingly in number, lack social interaction [31]. With the enormous growth in the telecommunication technology industry over the last decade, it has made easier to communicate with family, friends and colleagues. Also with the advent of Social networking sites social interaction has reached a new higher level but these technologies do not urge people to socially interact with each other without a reason, particularly if they haven't met before. We focus at encouraging casual social interaction between the people in a public space through games.

Since the last decade there has been an increasingly growing number of digital displays within an urban public environment of various sizes and shapes used for commercial and cultural purposes such as advertisements, news, drama, sports, music, documentaries, interactive games, even support during various events .To design digital contents to these screens it requires a clear of understanding for the nature and extent of public involvement with these screens, and design contents that requires interactive participation from users rather than providing contents with just peripheral passive engagement. HCI researches have started analysing the collaborative interaction of a crowd with technology and not just individual interaction with technology.

In this research we would concentrate more on the finding made till date on social and interactional behavioural perspective in urban public screen game which would provide some information regarding people's behaviours and interactions with the interactive game played on these public screens. Following the finding from various researches paper indicates the important aspects to be considered while designing interactive applications like games for public screens [17][18][19].

> ➢ Physical space, health and Safety of people in public space

Any content displayed on these public screens could have specific change in the behaviour of the crowd in the vicinity. For example, if a popular sporting event like a football match is telecasted, it may result in a large crowd gathering or with an interactive application which involves physical activity, is likely to intervene with other people in the surrounding or disrupt the movement of the crowd. It is important for context designer and the screen management to understand these factor and design contents or interaction applications that has minimum risk with respect to public safety, and also making sure that precautionary appropriate health and safety measures are in place during such events.

> ➢ Initiate participation among people

We could face difficult challenges while starting game especially in the absence of a compere as initially getting a lone volunteer to start playing the game is difficult. Since most people in this setting are unknown to each other and since physical activities are large and visible, evaluation apprehension would play a major role as it can even make a participant to withdraw from playing. People would like observing other perform from distance before they decide to try the game hence visibility of interaction is important.

Accidental interactions and a compere assist initiate participation to a great extent. Accidental interaction is when a person with no intent to play the game, walks through the interaction space which could result in initiating the game leads to unexpected participation. Simple demonstration game dynamics to the crowd could lead to participation.

A compere assists in drawing people to participate by explaining the game and helping them overcome uncertainties. Compere also plays an important role during the entire course of the game by interacting with the audience and players appreciating their action.

> ➢ coordinating collaborative play in public

Since these games are designed for public spaces where most of the potential participants and audience are unknown it is important to understand and design game so the participants break the ice communicating better so that coordinate their play and the make audience also involve in game. To introduce coordination among unknown participants, social meaning and social rules have be understood. Design games that have multiple levels ranging from easy to play –to- difficult to master and have game dynamics such that there can be flexible coordination. The game design should induce collaboration among strangers and should be designed for playability and spectatorship.

➤ Concept of using games as social resource

People in a public setting will not come with a main intention of watching the Big Screens and participating in the interactive game, rather they come to these public setting for relaxation or taking a break from their various routine activities and socialise with family and friends. Viewing the Big Screens and playing an interactive game can be used as an interactive resource to socialise.
In the public setting it is also necessary to keep the spectators engaged as they are also part of the setting and play in important fact on the player's performance. Example if the spectator encourages the participants, it enhances the performance.

Networking technology can be used to connect the large screens in various geographical locations (like different cities) so that the game can be played in a distributed manner. This also facilitates a sense of competition among the participant which result in greater interaction and give a good experience playing the game.

3.5 Exertion games

Games and sporting events/extravaganza have been useful in alleviating social interaction for player as well as spectators for long time now. Sports are one of those activities which are played and enjoyed by billions of people around the world, without any barriers of age, race or social status. Sports have dual advantage, of maintaining one's fitness through physical exercise, and increase the social interaction which is valuable for maintaining a healthy social relationship among family and friends. Sports also help building new rapport among people who has met before. These days, corporate sector uses games as a channel for team-building activity to develop rapport among fellow workers of new teams.

Exertion activities are those which require intense physical effort and is defined by Mueller as "exertion is the act of exerting, involving skeletal muscles, which results in physical fatigue, often associated with physical sport"[20]. HCI research community is fascinated with the discovery of a new genre interaction experience which involves the combination of user's physical activity (body/hand movement) with an interactive computing device. HCI researchers in games have proposed that the inclusion of bodily interaction enhances the player's engagement and also changes the nature of that engagement, from an "emotional" experience to a "social" experience.[21].Muller also defines exertion computer games as "a digital game where the outcome of the game is predominantly determined by physical effort "[22].

HCI researchers for a few decades now have been looking into human body movements and exertion activity involved in them. It was the novel idea of Mark Wieser's ubiquitous computing which gave a new dimension to the human body interaction with the computer technology. Since then, there have been various scientists who explored this field with different purpose and perspectives ranging from focus to avoid injuries

due to human body movement for computer interaction, to interaction with computational system in seamless manner. Each research approach looks at the interaction aspect of the body from a single perspective. It was hard to find any related papers that have the entire range of different viewpoint on the human body interaction in exertion activity with technology.

Using a framework dedicated to design exertion activity/game, otherwise the traditional frameworks of a passively-interactive button-press computer games, can provide a greater understanding of exertion games helping designers and developers utilizing the various advantages of exertion activity and develop an actively-interactive game.

3.5.1 A Framework for an Exertion game [22].

3.5.1.1 The Body lens

Muller developed a framework defining a conceptual construct "The body lens" which allows conceive of the body in exertion activity such as sport/game from four perspectives which then combined together, which can be used to design exertion games.

The human body is at the centre, surrounded by four layers given below:

1. The Responding Body
2. The Moving Body
3. The Sensing Body
4. The Relating Body

With combinational results of these four layers it is possible to acquire a body perspective information equivalent of four complementary lenses capturing body in exertion. This framework inclines to Jacob et al.'s framework which depicts the contextual components in the interaction with non-traditional non-keyboard operated system [23] [24].

3.5.1.2 The Responding body

The responding body lens gives inner perspective of the body in exertion, i.e. view from "from the inside", and how the body reaction and the resulting changes had happen internally due to the exertion activity the body is involved in. Such internal changes could be breathing is heavier, increase in player's heart rate typically increases and sweating. These changes are not intentionally started by the player, but are due to implicit biological changes that happen within the body due to the exertion activity.

The below diagram (Fig.3) depict a pictorial representation of the body lens structure.

The Responding Body

The Moving Body

The Sensing Body

The Relating Body
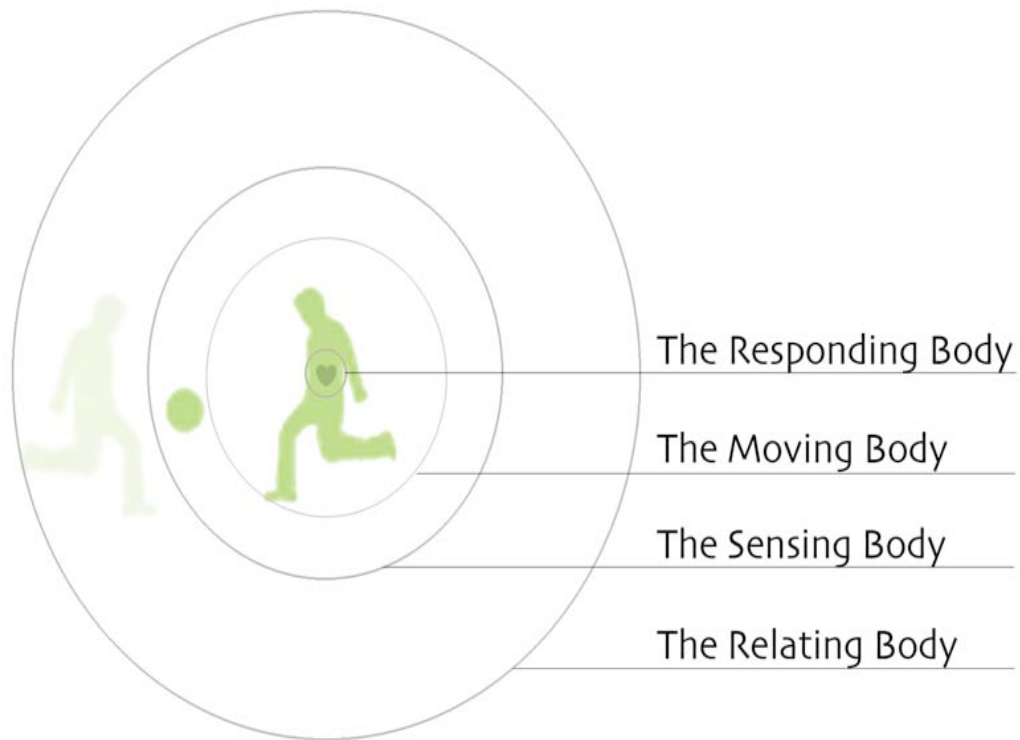
Figure 3

(Taken from Ref. [22])

3.5.1.3 The moving body

The moving body lens concentrates on players' change in muscular position of body parts due to the exertion activity involved. This viewpoint provides information regarding the human bodily movement characteristics such as intensity of the action, continuity in the action and variety in movements and also kinaesthetic sense (human ability to feel movements of the limbs and body) [2].

3.5.1.4 The sensing body

The sensing body lens is viewpoint providing information about the interactions between the body and its play environment, linguistic context of surrounding. The physical objects and technology is used in the game and the surrounding environment plays a vital role in the game dynamics. With the addition technology into the exertion game, the objects used in the game comprise of both physical and virtual article which make them more interesting.

3.5.1.5 The relating body

The relating body lens is perspective on the player's interactions with other participant and spectator during the exertion activity and how this effects on the players performance in a social play.

"The body lens" provides social structure on how the body in exertion interactions can be viewed helps to see exertion games from different perspectives,
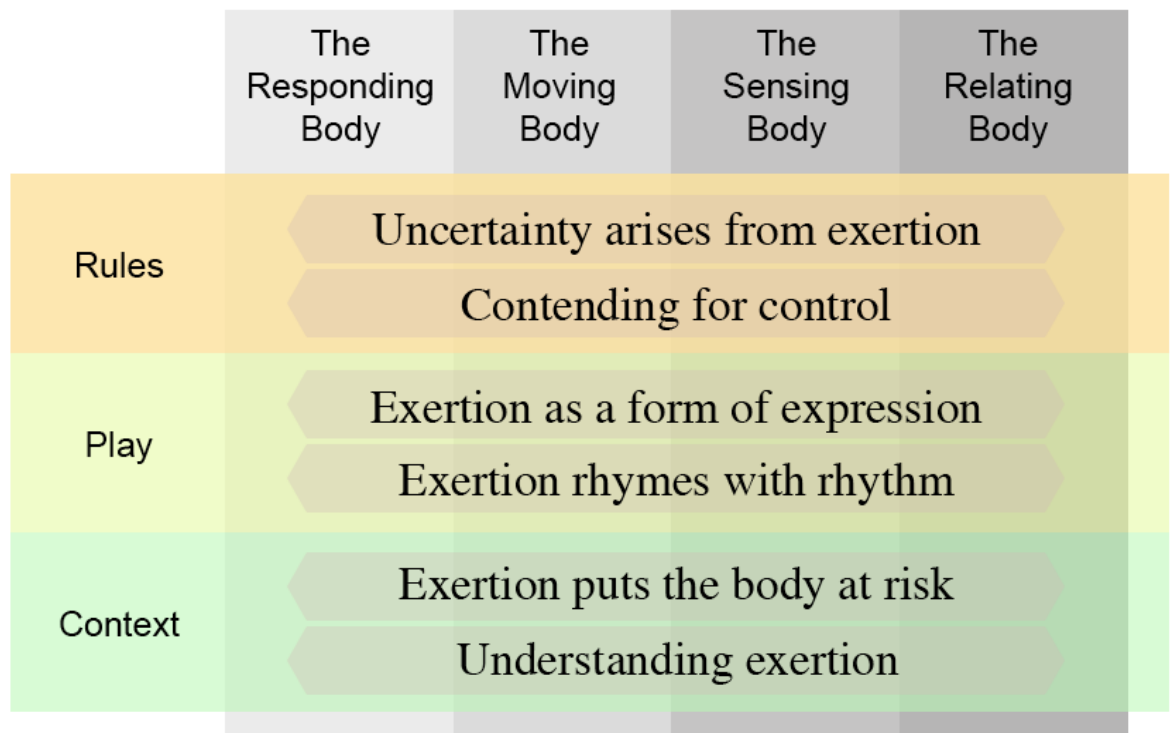
Figure 4

(Taken from Ref. [22])

3.5.2 Six primal themes of the framework [22]

This framework is for exertion in digital games, so they adopt the fundamental gaming schemas of rules, play, and culture from the past research in games [25].The above diagram (Fig.4) depicts a pictorial representation of the body lens structure.

- Rules give the fundamental structures of how the game has to be played.

- Play provides the experiences of the participants of the game.

- Culture proposes a high-level environment (setting) in which the game is played.

❖ Rules: Uncertainty of exertion

Uncertainty is a curial aspect of most games as it adds a suspense and surprise components in games making the game enjoyable and occupying action. In exertion games, greater level of uncertainty originates from exertion activity such as the exhausting players interaction with objects and environment unlike traditional button-press digital games in which uncertainty can be inserted only through explicitly programming it in game dynamics. This will help the designers use the uncertainty originating from exertion activity and adding to the uncertainty from programming aspect to provide greater engaging play experiences. The sensing body lens provides the uncertainty perspective.

❖ Rules: Awareness of exertion

With the technology the player can either be given or concealed with bodily information such as heart rate during or after the game. This information of cognizance physical effort invested to play the game can benefit the player, like make him utilise his energy so that he plays in controlled manner, compare it with others participant acting as a source of motivation to perform better. The Responding Body lens perspective acts the core for source and effects of the awareness of exertion.

❖ Play: Exertion in the form of expression

Metagaming refers to "what happens during a game other than the game itself" [25]. Flow of expressions is conceived as metagaming. In an Exertion Game player can use a broad range of metagaming actions to express the bodily ability. Though they burnt out energy and might not help in winning the game, but enhance the overall experience of the game. The Relating Body lens gives the perspective of Exertion in the form of expression as metagaming expressions are intended toward other participant and spectators.

❖ Play: Exertion rhymes with rhythm

Exertion rhythm in game is the ability of a game designable to confine to a consistent or modelled recurrence of the bodily movements. From the moving body lens perspective rhythm is comprised of the continuousness of movement, particularly when compared to a just a single action event in traditional button-press computer games.

❖ Context: Exertion puts the body at risk

This scheme spotlights on the exposure of the body to injuries due to exertion activity. Injuries are a part of most sporting activities. If injured in an exertion Game, results in an unpleasant body reaction such as experiencing physical pain but it also provide a

sense of excitement and achievement if we win the game by putting the body at risk. The responding body and the moving body lens can give a clear viewpoint on the risk on the body due to exertion.

❖ Context: Understanding of exertion

Understanding of exertion deals with the ability of a game design to help the player gain knowledge about their body. For understanding of exertion, two important aspects come into picture: knowledge and skill. Knowledge - information about one's body's response to the exertion activity and skill – is one's ability to perform, that has been acquired by training and practice. All the four body lenses help in design to understand exertion.

It is necessary for the player to understand the exertion and involve in the game accordingly. Four ways in which technology can be used to design games that support understanding of exertion are

1. Allow the player to manually select of the difficulty level.

2. Restrict the player ability in the game design to match this skill level.

3. Design game so that participants with same skill levels are competing with each other. This can be achieved through networked play.

4. Design for automatic change in game dynamics depending on the player's physical capabilities. One such design could be to adjust the difficult level based on whether the player is tired or not.

This gives a theoretical framework for exertion games with an exceptional focal-point on social play based .This framework comprises of 6 primal themes that contribute to the understanding of exertion games, which are developed with the 3 fundamental game elements as the base and provide different perspective view on the body in exertion from four different body lenses. This theoretical framework uses the already subsisting computer games theory as a base to develop with a consecrate framework on exertion games, using the combinational results of research from sports, HCI and computer gaming theory.

This framework is for exertion games with limited social interaction. It has element of social play with respect to multiplayer game but it is not designed with keeping public space in the view. I will be implementing our game based on this framework and analysis; it can be used for designing exertion games in larger social setting.

3.6 Previous and Related Work.

Exertion games, touchless interaction, interaction with large screens and context design for these urban big screens, are the trending topic for research in the field of HCI and Computer Science. Research has been done in the field to make Computer system in the human environment rather than forcing humans to get in the Computer system. The latest trendy researches in these areas are listed below.

There has been enormous research done with HCI games as the research area which has resulted in innovative game design with revolutionary and new interaction concepts which has changed the way the game industry now looks at HCI. With the help of this it was possible for developer to design successful games like Warcraft III, Half-Life and various other games [26].

The general notion of fun and pleasurable experience has gained tending importance and has emerged HCI design. There has been an extensive research on Exertion interface and games by Florian Mueller and various other research .Their contributions are immense. Mueller had provided a framework to develop exertion games a social play. It can act as base to develop any computer exertion games [18][27].Various exertion games that have been designed, like jogging over a distance, Table Tennis for three and Shadow boxing, provide the ways to implement this the framework. Microsoft has designed games with the exertion factor using there Kinect and Xbox 360[38]. But these games are designed for an indoor play.

In the field of touchless interaction researches have been made to implement touchless interaction in various complex situations like medical field. In [29] this paper, the touchless interaction has been researched to be implemented Image-Guided Interventional Radiology. In the past two decades there has been intensive HCI researchers resulting in wider perspective of new interfaces and interaction technics such as virtual and augmented Reality, Tangible and Physical Interaction, Ubiquitous and Wearable computing moving away from the traditional WIMP (window, icon, menu, pointing device paradigm. In paper like [30] which focus on the producing new interaction method and frameworks which is a path to develop tools for Reality Based interaction with consider body movements for interaction. Various inventions like Wiimote, virtual reality gloves [39], Microsoft's Hand gestures and webcam [40], Sixth Sense technology [41] have let to the growth of touchless interaction. But there is no paper yet on the touchless interaction with large public displays.

Anthropologist like Dr Kenton O'Hara has conducted various workshops [18][19] to analyse the interaction in public spaces. They have suggestions novel ideas for interaction public space which we will adopt in your project. In paper [17] they have designed a collaboratively played interactive game called the Red Nose game that is

played on a public large screen and involves some element of touchless interaction but lack extensive physical effort hence doesn't include exertion.

In this project, we will be designing and implementing an exertion game, which is collaboratively played in public setting involving touchless interaction with large display systems. We will focus on the getting exertion activity, collaborative touchless interaction and public large displays on one single platform of a game.

3.7 Summary

In this literature review we have obtained the great understanding of unique characteristics HCI, exertion games, and touchless interaction and have understood how to design context/games for big screens in public setting. It also provides some basic information about linear and structural interdependency among the various fields.

We have developed great understanding of HCI in general, the paradigms and current interaction techniques used in HCI, system architecture and the overall factors affecting the design of HCI. Gained greater knowledge in the field of touchless interaction and how it affects the HCI design. Also derived the on the role it play when designing digital exertion games .It was observed exertion activity places a major role in one's body fitness and its tightly coupled social play, as social play contributes the performance of the player in the game. From the wide range of research in the field of exertion games evolved a framework that was developed Mueller which we will be adopting to design our exertion game. It was observed that fun and motivation play a major factor in the design of context for the big screens.

The review highlighted the fact that currently there was no single paper/research that provides information for design of an exertion game to be played on the large screens public setting. There are literatures on individual elements but not for a combinational requirement of designing an exertion game with collaborative touchless interaction as a part of the game dynamics which is played on big screens in public setting. This is important because people like to socialise and exercise at the same time and it is vital to consider collaborative touchless interaction with the large screens, as these screens are proliferating in the urban public environment.

4. DESIGN AND IMPLEMENTATION

In this chapter I talk about design and implementation of an exertion game/system that was developed for public setting with touchless interaction based on Mueller's Framework.

4.1 Introduction

With respect to this research requirement, I developed a game called, Human Pong which allows people in public setting to play sports/game/physical activity with each or alone. It includes a large display system like the BBC big screens in cites in UK plays a major part of the game setting. This gives a unique way to interact with the large screen and also start a conversation with others. All three aspects of the research including Muller's exertion framework was considered during all stages of design and implementation. The game and its setting provide a floor of opportunity for experiments intended towards social gaming, as it has been successfully tested and played by more than 100 participants.

4.2 Design of Human-Pong

I developed a game which allows one or more players to play the game, in which the body of the player will represent the paddle and its position is determined by the human movement, which is captured using a camera. The main aim of the game would be to make the opponent miss the ball. Players can move left-right from the screen or front-back to hit the ball. Their movements will be captured using the camera and used to move the paddle on the screen. It requires a high level of exertion from participants through running and (perhaps) jumping& sitting.

4.2.1 Design Goals

The main goal was to design the game based on Mueller framework for exertion game and also making the game fun to play and create opportunity for interaction & collaborative play between participants. It was necessary to implement touchless interaction with the large screen.

4.2.2 Game Dynamics

The game can be played individually or in teams. A team (containing 1 or more players) can play the game against a computer. Each team continues to play until the ball misses the paddle a set number of times (tentatively 15 times but can be changed) and the time of play is calculated. The team with the highest playtime will be displayed so other teams/players can try and better that time. But the primary motivation is to make people move and get a workout. We anticipated each game to last around 5-25 minutes based on the individuals' involvement and fitness. As this game requires greater

physical activity suitable warning information and instructions was provided to them at the beginning of the game.

The game could be played in 3 different modes.

1. Computer versus Human

2. Human versus Human

3. Computer versus Human Team(2 or more people)

The player movements are mapped to the paddle on the screen as follows. When a player moves left the paddle moves down, player moves right paddle moves up, when player moves front the paddle moves toward the middle and when player moves back the paddle move back. The mapping was designed so that it makes the player think before they decide moves adding an element of difficulty to master the game.

In the game, the spot where the ball hits the paddle play an important role. When the ball is moving up, if the ball hits the lower half of the paddle the ball changes its direction to move down and if the ball hits the upper half of the paddle the ball continues to move up. When the ball is moving down, if the ball hits the upper half of the paddle the ball changes its direction to move up and if the ball hits the lower half of the paddle the ball continues to move down. With this game dynamics it gives the player a control to decide the direction of the ball in which the ball should move after hitting the paddle, making the game more interesting and fun also trying to maintain an element of surprise to keep the game lively.

With respect to Muller's framework, the above designed game satisfies all four lenses on the framework. The responding body and moving lenses gives inner perspective of the body in exertion and change in muscular position of body parts due to the exertion activity involved respectively. In this game most players are expected to experience some kind of internal changes such as breathing heavier & sweating as a result of running around.

From the sensing body lens and the relating body lens viewpoint, the player has to interact in touchless manner with the large screen just by performing an exertion activity like running, jumping or sitting based on the player's creativity and ability and also co-ordinate & talk to other player to play the game more efficiently. Since the game is played in a public setting it gives a great view from the relating body lens perspective as the player should perform in front of huge unknown audience.

Based on the design experience it can be concluded that at present, the current state of the Mueller framework befits in developing the game/system we are intending to

research, i.e. a computer game, with high level exertion required to play the game, for large screens in urban setting having touchless interaction with those screens.

4.3 General Game Setting

The below pictorial representation give a general/ideal game Setting for the above designed game.
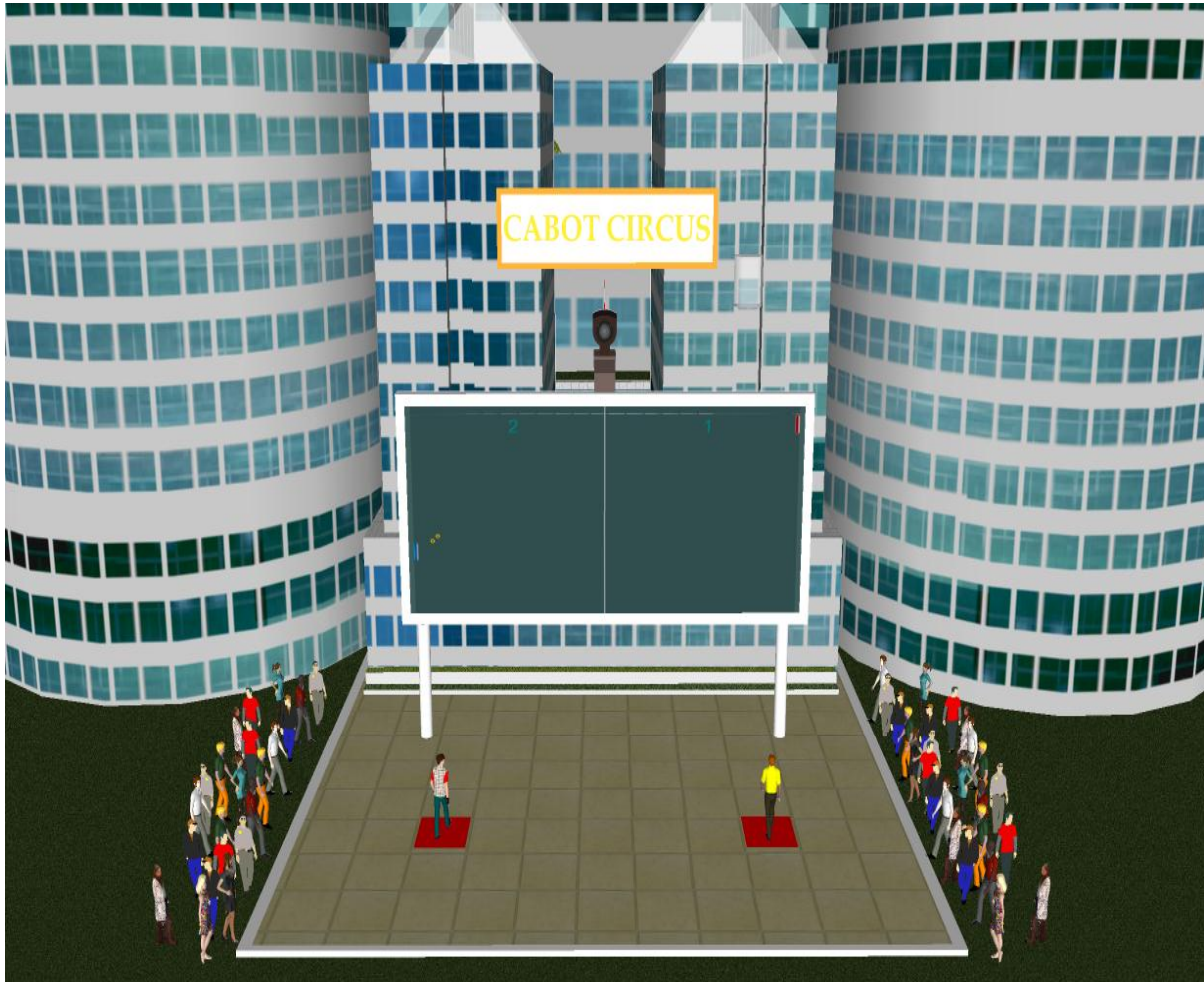
Figure 5

Such setting can be found in various cities like the one at Millennium square at Bristol harbour side, near the city centre shopping mall (Bull Ring) at Birmingham and various other locations. At the game venue we need large screen (5m * 5m) with camera with computer to run the game. A mike and speaker would enable compering and music can be played during game to provide certain feel. Certain area in front of the screen is cordoned off as playing arena and the camera is adjusted so that it focuses only that particular area.

4.4 Implementation

The implementation of Human-Pong went through various stages with feedbacks from lot of players. Human-Pong was first played with family and friends before it was exhibited to the public for research purpose.

The Human Pong basically consists of three major components in the Game Setting:

1. Large Display Screen in public setting.(Hardware)

2. Camera to capture player movements.(Hardware)

3. Game/Physics Engine.(Software)

Large Display Screen in public setting.

I wanted to run the game at one of the BBC screens but was unable to do so, due to time issues. Instead, I used a projector to replicate the Large Display system. Large screens play vital role in the public setting as they form a means of communication channel for interaction between people in a public setting. One of the requirements of the system in research is to be able to interact with such large screens in a touchless manner. Above research criteria lead to the use of the next component the camera to track human movements.

High speed Camera

It plays an important role in this system setting as it capture's player movements during the game which is used to map the player position to the paddle. As shown in the Figure [5] the camera is placed above the screen or the lower frame of the screen at an angle of 45 degree to the plane of the ground so that human upper body can be easily detected.

Game Engine

This components focus on getting the exertion activity into the game. The video feed from the camera is passed to this Game Engine where the position of the human is identified using a Haar Classifier. The Game Engine is developed using C++ programming language alongside using libraries like OPENCV & SFML and Openframework, which can be run on windows machine.

1) Opencv & Haar Classifier – Image processing for human body & position detection.

2) Open Framework (videoInput) – capturing video from the camera.

3) Simple and Fast Multimedia library (SFML) & OpenGL - Game graphics.

4) Gimp, Inkscape and Adobe Photoshop online was used to draw images of the paddle and ball
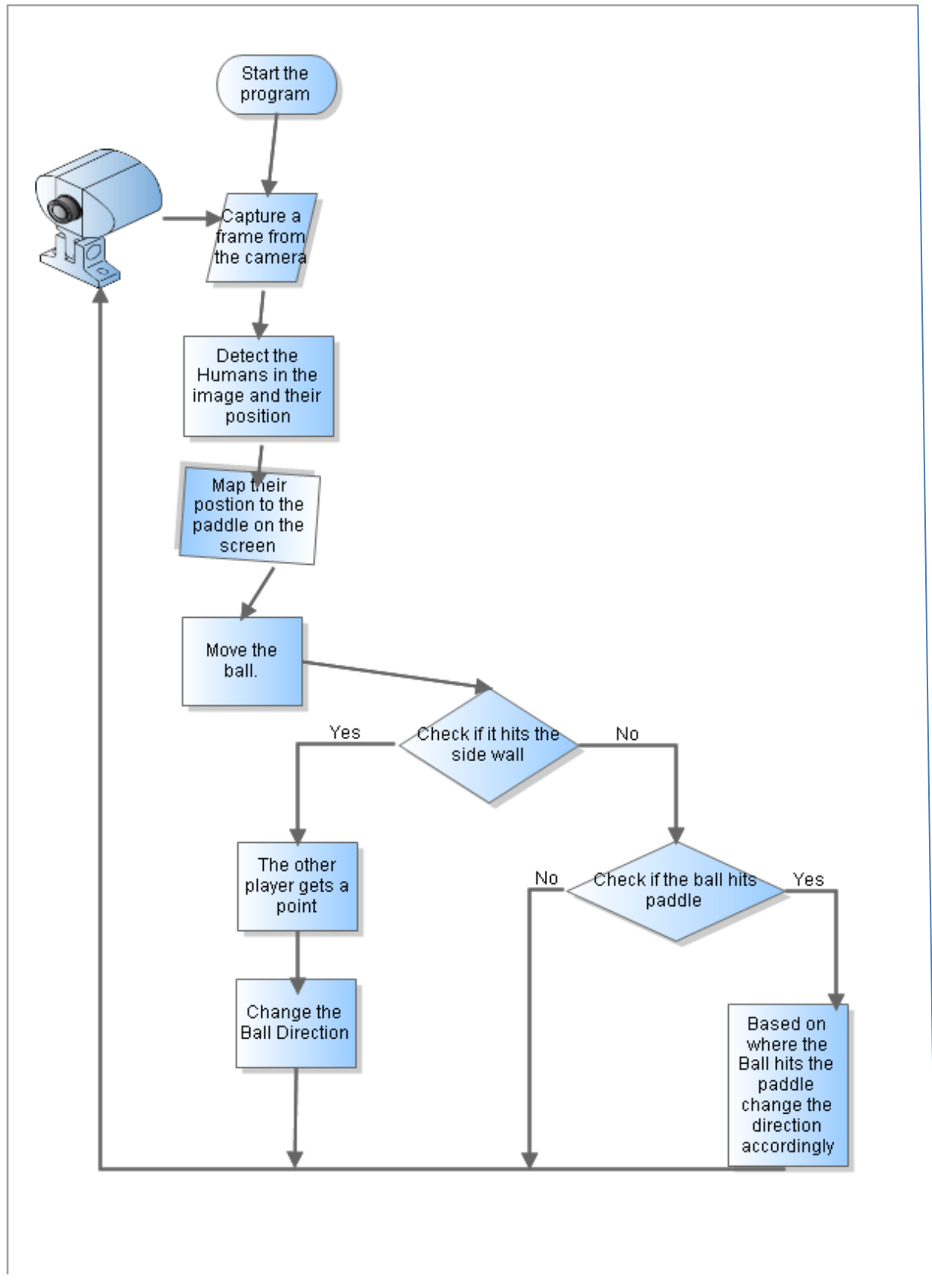
Figure 6

The above diagram provides just an overview of the main functions of the Game Engine and doesn't represent the entire Game Engine.

Opencv is an open source computer vision library is written in C and C++.Open CV enables building of a fairly complex vision applications at a faster rate due to the presence of its easy to use vision infrastructure. It contains more than 500 functions useful cross various aspects of computer science [41].

"Openframework is an open source C++ toolkit for creative coding."[42] It contains various libraries like OPENGL, videoInput and many more at one single framework that help for easier and faster development. SFML and OPENGL are simple and efficient graphic libraries that are used to develop the game graphics.

As the game engine starts it loads the graphic of the game, which is designed using SFML and OPENGL with openframework. The options are provided to select the type of game. Once the game starts the main functionalities using the camera connected to the system it starts captures the live video. This grabbing a frame from the camera is implemented using videoInput in openframework. Taking the frame from the video, the game engine detects humans in the image and captures their position. This is done using Opencv and the Haar Classifier. I have used a various Haar Classifier xml file for this purpose. These files are not written by me, I have just used it in my game engine. In this we detect the player based on the upper-body. The game engine is coded to detect using the lower body and full body also but wasn't used and has been commented in the code. The detectPlayer method in the game engine has implemented this functionality.

Once the human position is identified it is then mapped to the paddle on the screen. The game engine is programmed to ball move .When the ball hits the upper or lower walls of the screen it just reflects and continues to move. If the ball hits the side wall of the player missing the paddle that represents him the other player scores a point in the game then the ball automatically changes direction and the players continue playing without a break. This was designed to make the player get an exertion or if the ball hits the paddle the direction of the ball is changed according to the position where the ball hits the paddle as explained in the design section. So it depends on player on how fast the paddle moves and in which direction the paddle moves. In this way I incorporate touchless interaction with the large screen.

This entire process repeated again and the players continue playing by running around till a maximum score is reached. This maximum score is set in the beginning before the start of the game. At the end of the game a message will be displayed informing who won the game, the score and how long the game lasted for.

This game satisfies all the 4 body lenses of the Mueller framework and also the six primal themes of the framework. There is no time gap between each point. This is done to give the player maximum experience of exertion and make it easy to lose a point which will make the game more interesting. And with respect to the change of direction for the movement of the ball after it hits the paddle depends on where it hits the paddle. This can be decided by the player by altering his movements and make the opponent

curious about this adding fun and existing by maintaining an element of surprise. This also makes the game difficult to master.

Since the camera frame-rate was very slow, I used free software called Manycam to get the input of the camera since this gave more frames per second. But even this was slow but much better. This doesn't require any changes in the game engine code just need the software to be running on the system.

4.4 Summary

This chapter talks about the design of the human ping pong game. It was designed based on Muller's framework. This chapter also touches upon the 3 different modes of playing the game and how touchless interaction was implemented. It also gives a snapshot of the general game setting and also a flowchart of the basic working of game engine. The implementation gives the technicalities of the game through game engine development.

5. EXPERIMENT

5.1 Introduction

This chapter gives an insight into the demographics of the participants involved in the experiment. It describes the process involved before, during and after the gaming process. It also gives the manner in which the feedback was taken through questionnaire and interviews.

5.2 Participants of the game

More than 100 people played the game. Out of which 63 volunteers gave a feedback by answering the questionnaire and the participants were personally interviewed together. Since the game was played in a public setting, people around at the game venue during the experiment played the game. None of the participants were personally invited. The game was advertised through social Networking sites like Facebook and a few posters were put up at the venue few days before the game. None of the participants had prior knowledge about the game. Since this game was designed to study the exertion games in public setting no special arrangements were made to contact people just for the experiment.

Out of the participants who provided the feedback 39 of them were Male & 24 Female. People of all age groups participated with the youngest being 16 to the oldest being 38 with the average age of participants being around 24 years with 65% of the participant from the age group of 20-30 years who provided feedback.

Every time two participants were randomly asked to play the game from the crowd. First the participants played the game individually against the computer. Then the participants played against each other. Later the two participants teamed up to play against the computer. No participants knew each other before taking part in the experiment.
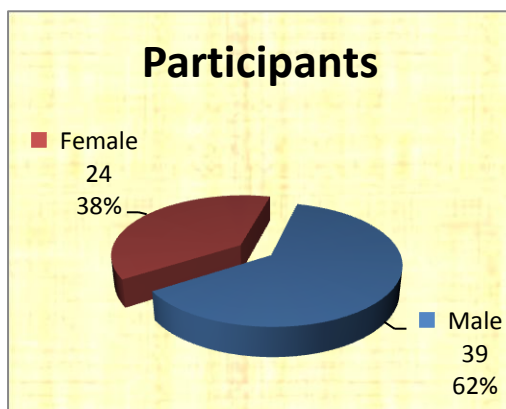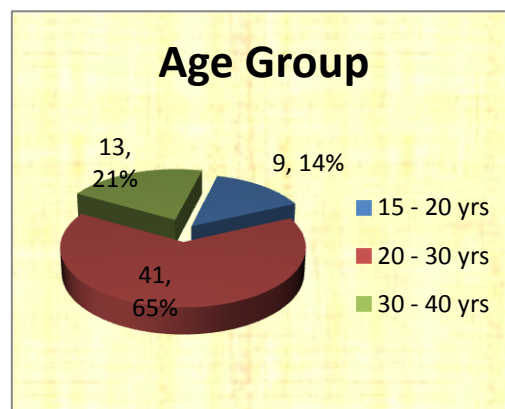

Figure 7

Figure 8

5.3 Rating & Feedback

5.3.1 Questionnaire

At the end of the experiment (after playing 3 games), the participants were asked if they could take part in feedback session and the willing participants were given with a questionnaire (9.1 Appendix). It has 32 questions distributed over all the aspects of the research and included detailed didactics. After a closer look into computer arbitrated interaction experiment/studies and based on the questionnaire used in those experiment [32] [33] [34], the questionnaire was prepared. The primitive goal of this questionnaire was to acquire clear &deep perception of how good the pair-participants got to know each other, how did the setting help the in participant interaction, their opinion on social exertion activity and how the game could be improved. Conversely the various precincts of the data from the questionnaire were accepted and the necessary additional methods like interview were used get the feedback [35].

A few questions in the questionnaire were based on the experiment and questionnaires based on related studies which helped later to compare the findings and derive at a conclusion [32] [34] [36] [32].In order to handle the sequence effect questions were randomly posed in the questionnaire. A few questions were in part negatively created/presented in the questionnaire to avoid recurring reaction pattern [36].

To prevent the Halo effect [35], detailed didactics were also the part of the questionnaire asking each participant providing the feedback to devote their attention while answering the question. Anonymity and confidentiality was assured, and maintained. Except questions of a statistical type (like sex, age), rest of the questions were to be answered on a scale of +2 to -2, ranging from strongly agree to strongly disagree.

5.3.2 Interview

Participants who played the game and were willing to provide some more detailed feedback and wished to discuss with us more about the game, setting and the experiment were interviewed personally. They were asked question mentioned in the below appendix section 9.2 .Some willing spectator were asked general questions about the game and their suggestions about the entire experiment was gathered

5.4 Experiment Process

The experiment (game) was played in 3 different locations (Bristol, York and Bangalore) with help of family and friends. Due to timelines we were unable to run the game on the BBC big screens. Instead we used projectors to replicate the big screen effect in a public space. In all the three locations a compere hosted the game. No one was forced to take part or play the game. Since the game involved exertion activity suitable warnings were informed to the participants before they started playing the game.

Figure [9] shows the sequence of events during the experiment. The experiment is classified into 3 major events, are explained below.
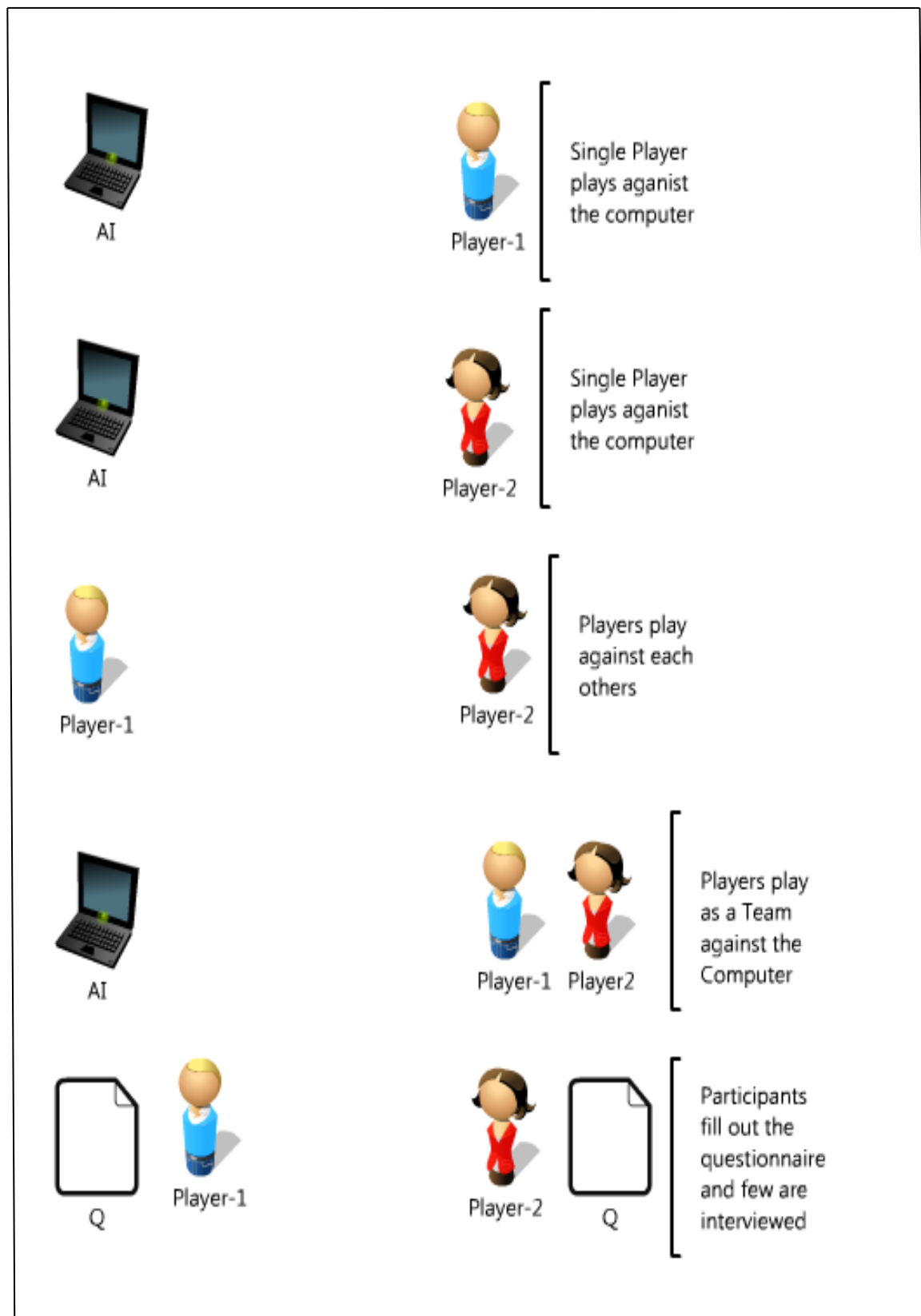
Figure 9 –Experiment Process

I used projector to replicate the large screen effect. At two locations we had the projection on white screen and at one location we projected on a wall. Due to hardware issues (Inability of system with 6pin fire-wire port) we weren't able to use a High speed - High definition wire-fire camera. Instead I used a 3MP Wide-angle Microsoft camera at one location and 10MP Wide-angle Logitech camera at the other two locations.

I was personally present at one location (Bristol) to conduct the experiment. At the other two locations (York and Bangalore) the experiment was organised and conducted with help of family and friends; but I was monitoring the experiment proceeding throughout with the help video calling on Skype. The experiment was conducted for two days at all the 3 locations from 9am to 5pm on each day. We reached the experiment location well in advance to make all necessary arrangements. I wanted the experiment to be hosted by a compere, so my friend hosted the game in Bristol. I explained the game to the participants and interviewed them after the game. Water was provided to the participants after the game.

Before the Experiment

Each time two people, randomly chosen from the crowd, who were interested in playing in game, were asked to step forward. They were given few minutes to introduce themselves to the other person. Since this game involved some physical activity like running, the participants were informed of the impact and were also auctioned. Then a brief description about the game was provided.

During the Experiment (Playing the Game)

In the entire experiment each pair played a minimum of 3 Games. First game each participant played the game individually against the computer. This is done to give the idea about how the game is to be played. Then they played game against each other. Finally each pair played as a team to against the computer. Each individual participant could play any number of games with as many people he/she wished to. The pair could have played as many numbers of games they wished. Most pair played 4 games with the last one either play against each other or playing as a team against the computer.

After the Experiment

After the game the participants were asked if they wished to take part in feedback session. The willing participants were handed over the questionnaire. Most of the participants completed answering to the questionnaire within 15 minutes. A few among them who were willing to provide more feedback were interviewed and their feedback was written down. The participants were provided a 5mins break before they were given the questionnaire. This time was used for resting and interacting with the other player by the participants.

5.5 Summary

This chapter talked about the participants in the gaming process and the mannerisms through which the experiment was conducted. It gives a summary regarding the rating and feedback of the customers through various questionnaires and interviews. The gaming process is also discussed. The experiment was conducted in a public setting with a compere hosting the game. Over 100 people played the game and 63 participants provided feedback by filling out a questionnaire and the team of players were personally interviewed together.

6. RESULTS & OBSERVATIONS

During the analysis of the feedback provided by the participants through the questionnaire, the questions were broadly classified into group, with question based on similar topic in one group as it was easy for evaluation and comparison. With the insight to prevent the Halo effect [35] certain questions were negatively worded, however was reversed while drawing conclusions.

Based on the five Likert scales [37], the feedback for the questions were rated and mapped to a scale from +2 to -2 as shown below.

+2=Strongly Agree

+1=Agree

0=Undecided

-1=Disagree

-2=Strongly Disagree

6.1 Based on Questionnaire

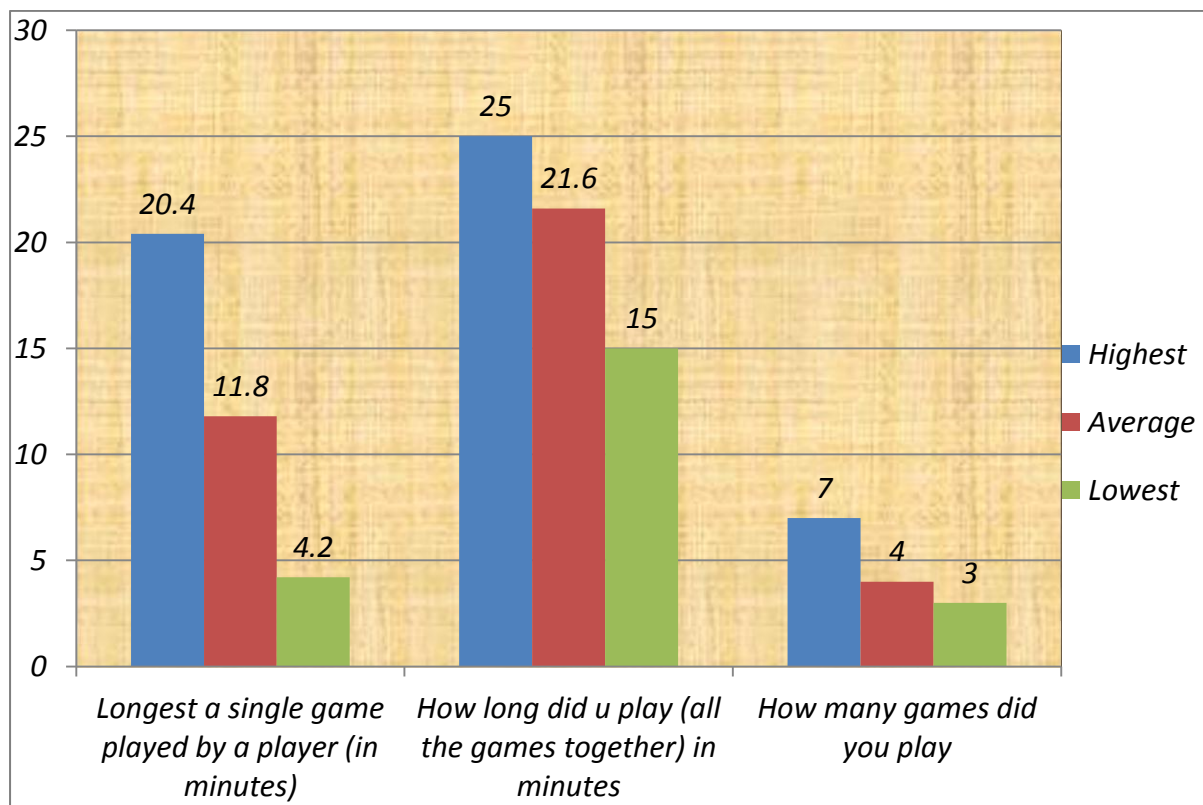### 6.1.1 Physical exertion experienced by the participants.

Figure 10

❖ These numbers indicated that the game exposed players to a lot of exertion activity resulting in heavy breathing and also excessive sweating for a few players.

❖ With respect to most players the first and the second games lasted for short time (around 4 -6 minutes each) whereas the last round was their longest game (around 12-15 minutes) during the experiment. Most players who wished to play longer were unable to do so because they were exhausted. This was seen during the experiment and most players acknowledged the same during the personal interview.

❖ Each player who participated in the experiment had atleast involved in physical exertion activity (running) for a minimum time of 15minutes but an average play was around 21 .6 minutes. Even though this wasn't a continuous play, the time gap between the last 2 games for each pair of participants was less.

❖ Each player played 4 games on an average. The duration of play and number of games played is directly proportional to the physical exertion experienced by the player. This provided the player a good measure of experience exertion in public space.
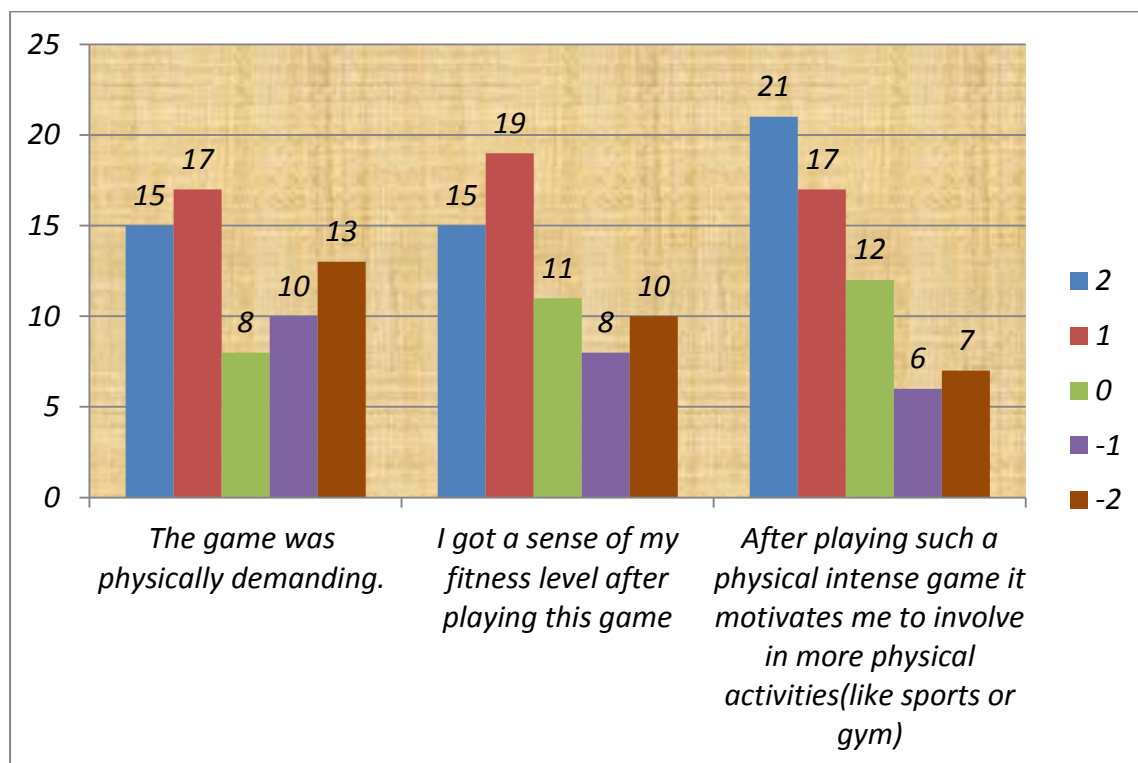
6.1.2 Sense of Exertion/physical fitness from the Game

Figure 11

❖ About 51 % of the player experienced that the game was physically demanding where as 36% felt that it was not physically demanding indicating the game posing no difficulty to play and 13% of the participants expressed that the game was neither physically demanding nor easy to play.

❖ Also 54% of the participants felt that they got a sense of their fitness level after the exertion activity in the game while 28% were still unsure about their fitness level and 18% opined that the game did not help them figure out their fitness levels.

❖ Around 61% of the player expressed that after playing the game it motivates them to get more involved into gym or sports assuring the finding that the game provided an experience of exertion activity to the participants. 20% of the participants said they didn't get motivated and 19% had mixed feeling about involving themselves in more such physical activity.

Overall from the statistical viewpoint more than 2/3 of the participants experienced exertion and also they were motivated to sweat-out more in the upcoming days. This was one of the main aims of the experiment and the game design.
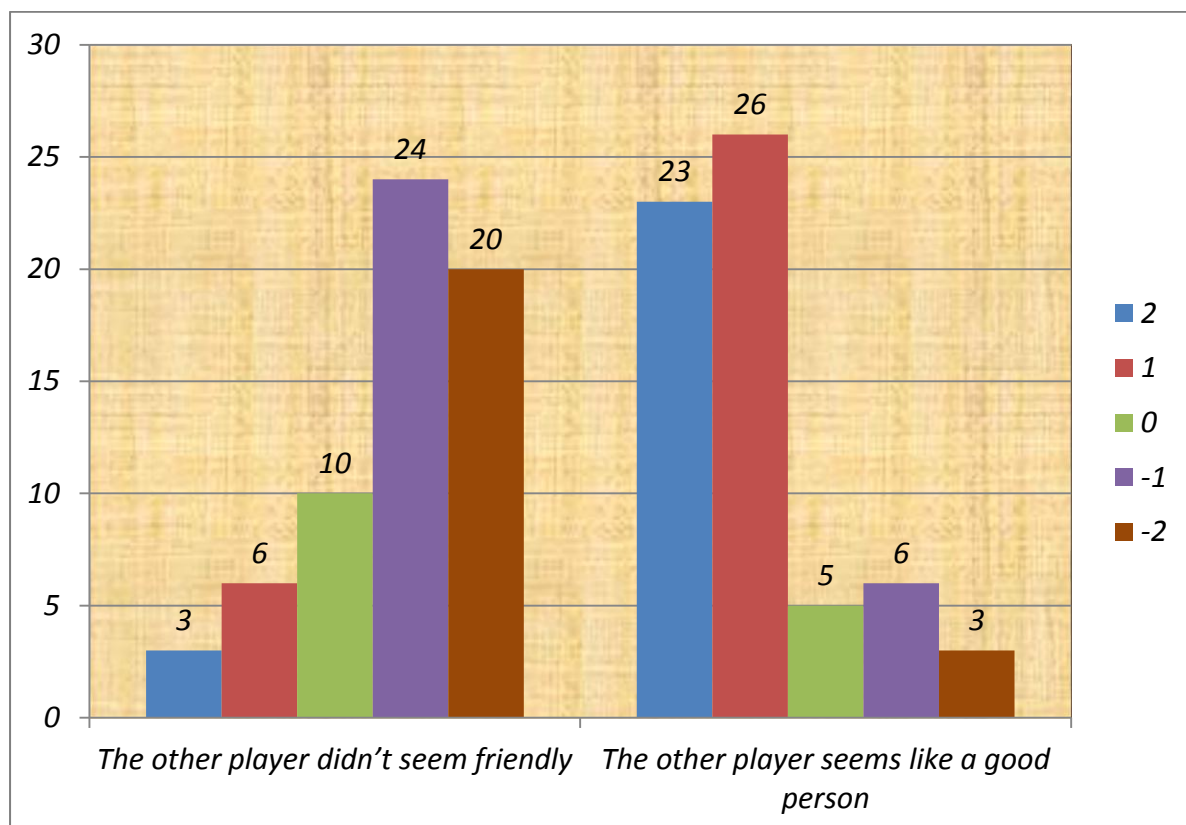
6.1.3 Impression gained on the other participant.

Figure 12

❖ Based on assessing the answers to questionnaire, about 70% of the player got an impression that their partners who played the game alongside him/her as team or against him/her was a friendly person (Figure 40). Only 14% of the participants agreed that their partner was an unfriendly person and 16% of the participants were unable to figure out whether their partner was a friendly person or not.

❖ Most of the participants were of the opinion that the other player seemed like a good person. These formed about 77% while the remaining 14% dint find the other player to be very good person and about 9% were unable to decide about the other player.

❖ The game played a significant role helping players get comfortable with each other, which was easily seen during the interview after the game. This game helped two strangers meeting in a public space overcome the initial communication barriers assisting them to interact with each other in a more relaxed and enjoyable manner.
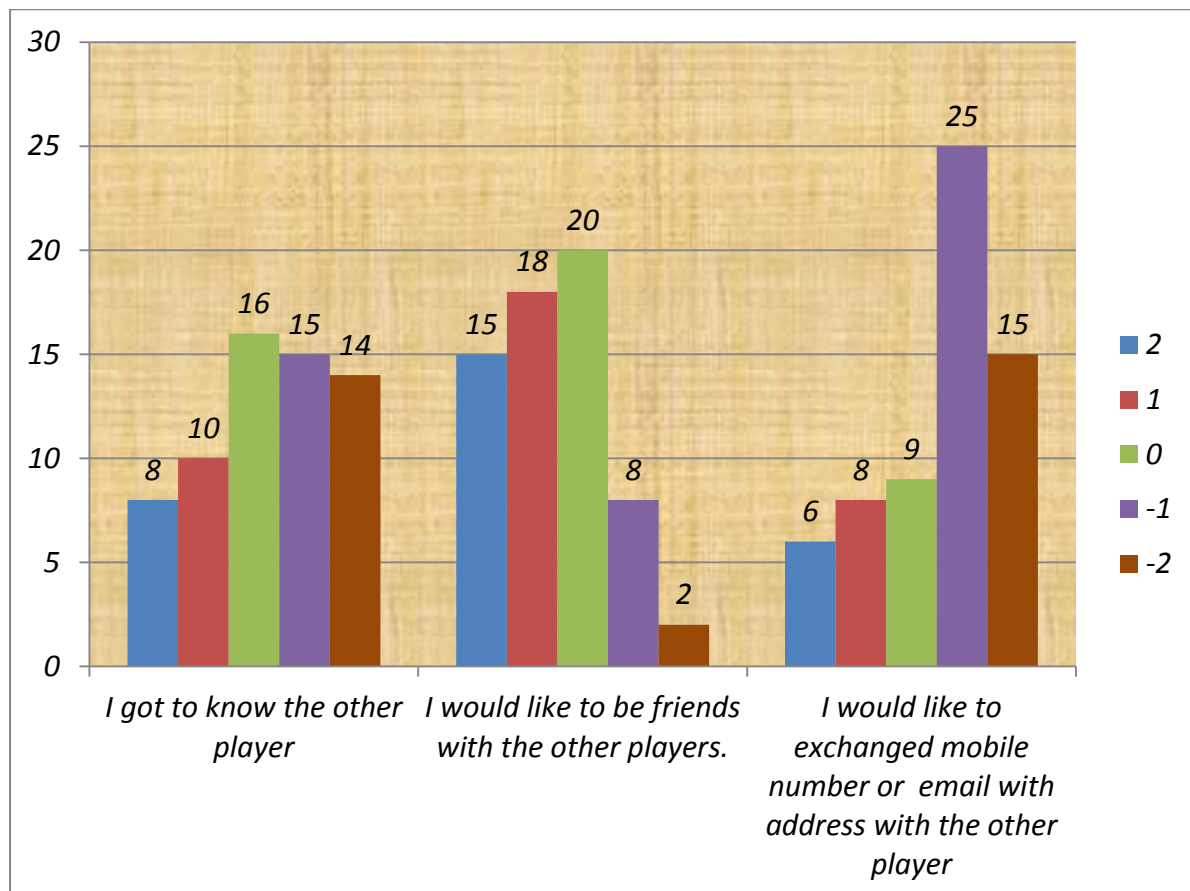
6.1.4 Social Bonding

Figure 13

This provides an insight of how well the two participants got to know each other and their extent of believe on each other so that they can share their personal details.

- ❖ About 46% expressed the fact that they didn't get to the other person that well, where as 25% we unable to decide whether that knew their partner well or not. 29% were convinced that they got to know intricate details about the person helping them get to know the other person.

- ❖ On the side, 53% of the participants wanted to become friends with their partner which is great start to get to know the other person. Around 31% were not sure if they wanted to or not become friends with their partners. About 16% were not interested in extending their kinship beyond the game, expressed they didn't want to be friends with their partner.

- ❖ Even though half of the participants wanted to be friends with the other player only 22% were willing to exchange their personal contact details with the other player. About 14% were unsure and remaining 64% didn't want to exchange.

This provides important information that the game just acts as an ice-breaker between two strangers.
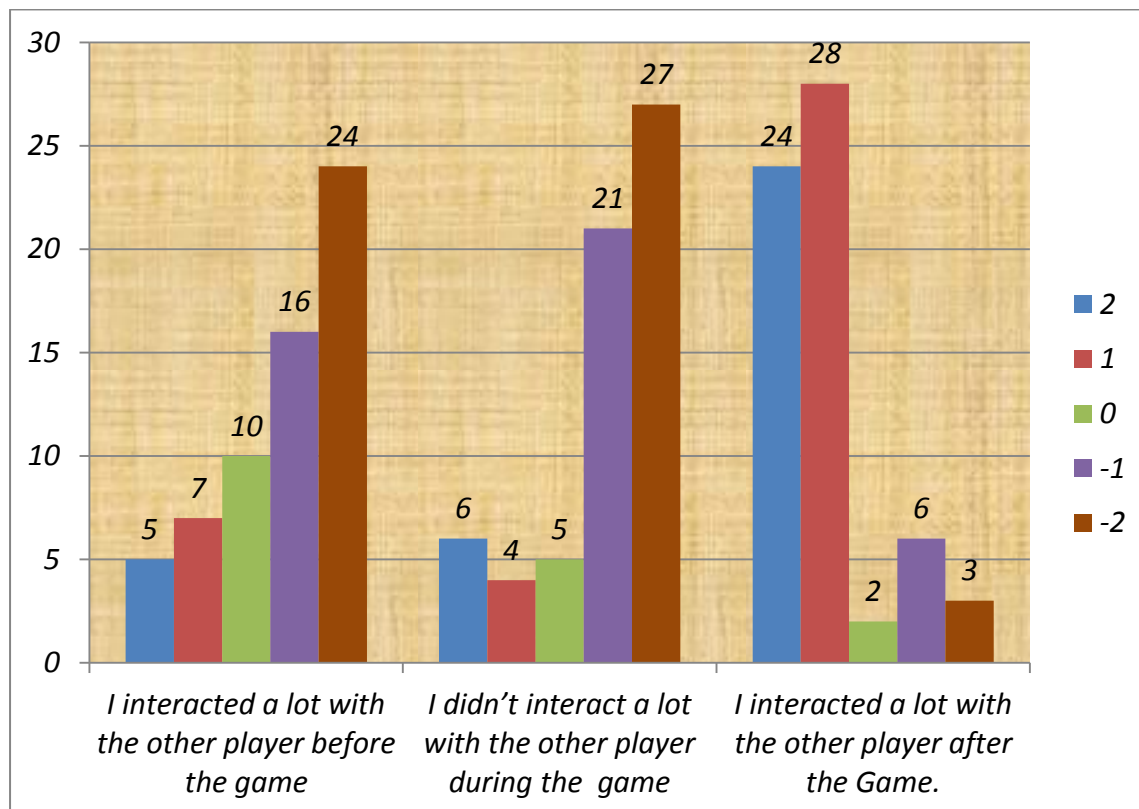
6.1.5 Interaction between Participants

Figure 14

❖ About 73% of the participants didn't have an interaction or a conversation before the game. Only 17% had interacted a lot before the game. This interaction was during the initial introduction time.

❖ About 77% interacted a lot during the game. These interactions were either during the break between each games or the last round when they played as a team. This helped the players to get over the initial communication barriers. Only 15% of the participants didn't interact a lot during the game.

❖ After the game most players had great conversation with a hearty laugh about their performance with the other player. This was acknowledged by the feedback as 83% of the expressed that they had interacted a lot after the game. There was break for about 5mins after the game (after 3 rounds) for the player to rest before they could take up the questionnaire. Most participants had good conversation during this break.

It is very clear from the feedback that, two strangers who didn't interact before the game ended up having a conversation during and after the game. One of the main goals of the game has been achieved.
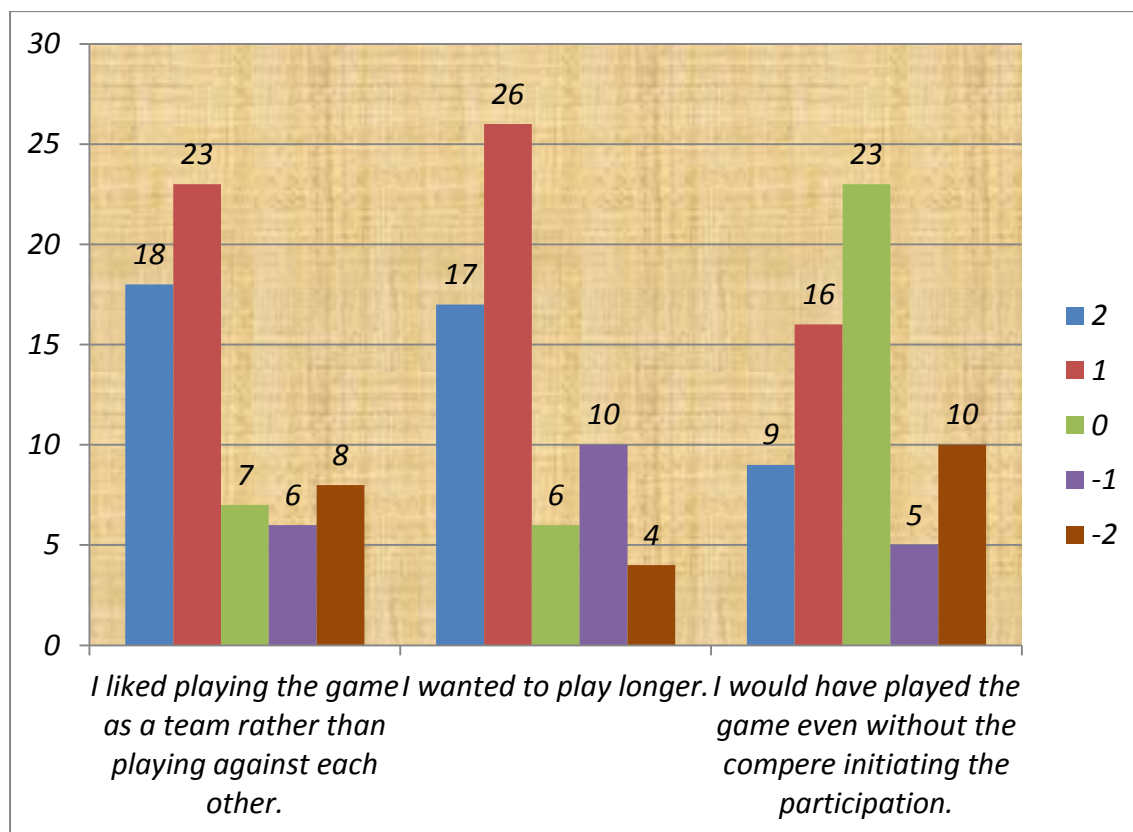
6.1.6 Playing a team or against each other.

Figure 15

❖ Most players enjoyed the 3 round (game), playing as a team rather than the 2nd round (game) playing against each other. About 66% acknowledged this fact in the feedback whereas 11% felt they enjoy both the rounds and the 23% of the participants enjoyed playing against each other.

❖ Participants were having fun during the game and most wished they played longer. This was also seen in the feedback as 68% expressed the desire to play longer. Around 10% were not sure and remaining 22% didn't want to play longer. When asked y so most of the player said that they were tired after the 3 games.

❖ In all the three locations the game was hosted by a compere. We asked players if they would have played the game without a Compere, about 40% said yes. But 35% could decide on that and 25% of the participants said they wouldn't have participated without a compere initiating participation.
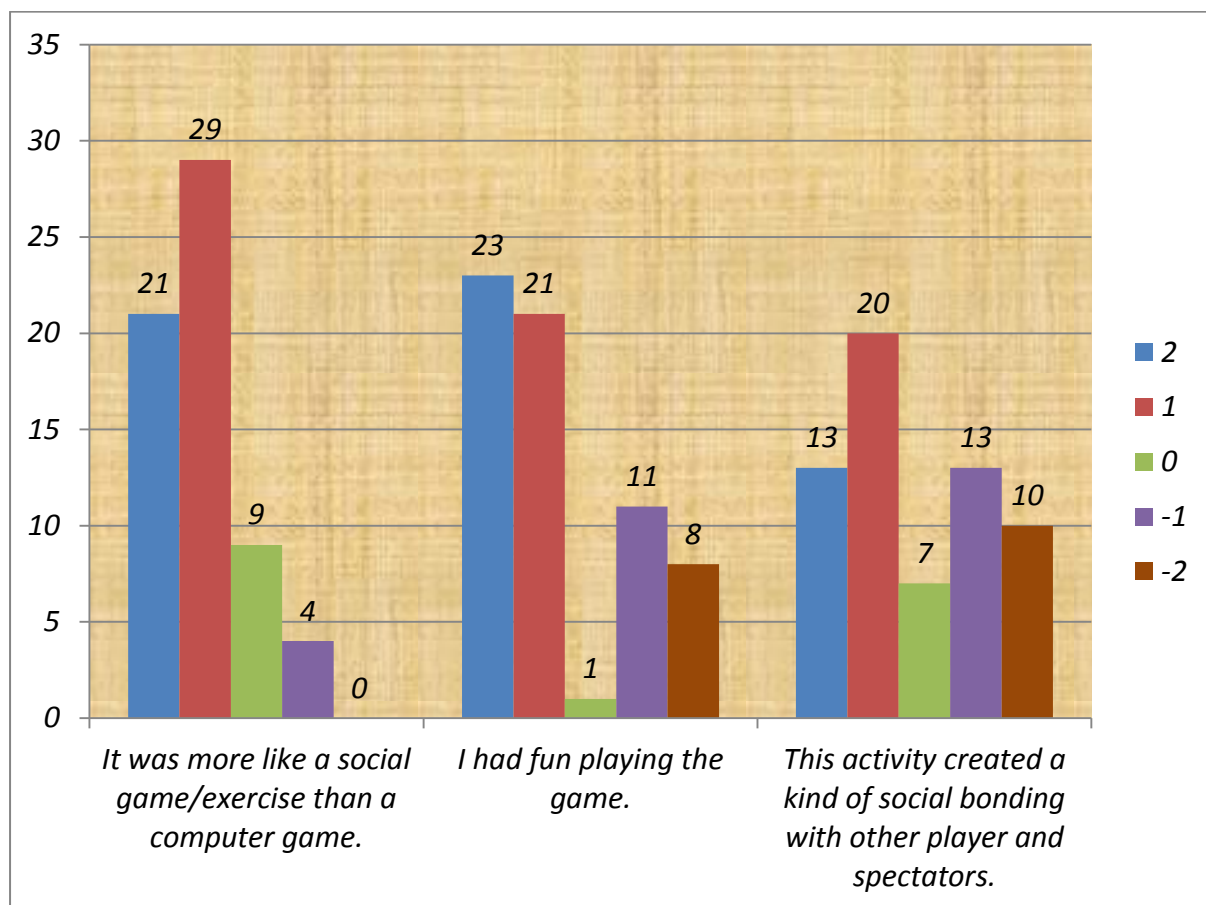
6.1.7 Collaborative Play.

Figure 16

In this part we start analysing the participant's opinion on the collaborative play.

❖ Due to the essence of the setting and the nature of the game we asked the participants where it was equivalent to playing a sport. Most participants expressed the fact that it was it was more of social game than a sport. About 79% accepted this. Hence it is clear that such games in public setting are not replacement to sporting events.

❖ Around 70% of the participants had fun playing the game where as other 30% expressed it wasn't fun playing the game. The game kind of provided a medium to having fun in public place the people opportunity to interact with people around.

❖ About 52% expressed that the game created a kind of social bond with the other player and spectators who were strangers before to him/her before playing the game. This suggests that the game in public setting can act as ice-breaker and help kick of conversation between strangers in a public setting which being of the important aspect of the game design.
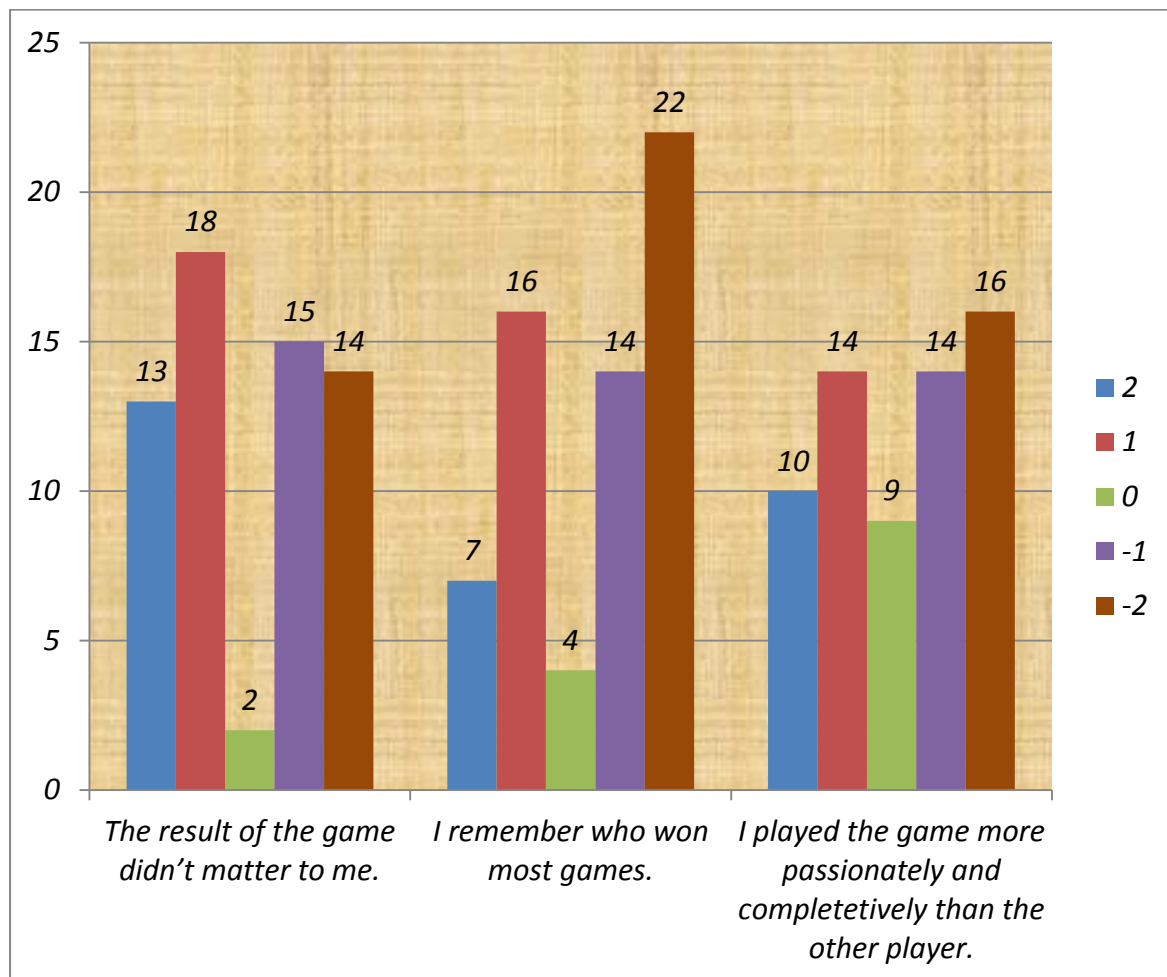
6.1.8 Fun or Competition

Figure 17

I wanted to get an over-view if the game was taken seriously or just playing more in a friendly and fun filled manner in a public setting as it will give some details and help designing further game.

- ❖ About 49% of the participants said that the result of the game didn't matter to them indicating that they played the game in less competitive sense whereas 46% said that they cared about the outcome of the game hence they played more passionately. When asked y so most players during the interview most players replied that due to the fact that the game was being played in a social setup with many passer-by's watching the game giving a motivation for the players to perform better.

- ❖ When asked about whether they remember who won most games around 57% said no and 36% said that they do remember who won most game.

- ❖ When asked about who played passionately and in a sense of competition around 48% said the other player where as 38% felt they played.14% of the participants felt that both played being equally passionate.

This indicates that player get under some kind of pressure when performing in front of a crowd even when they are playing the game for fun.
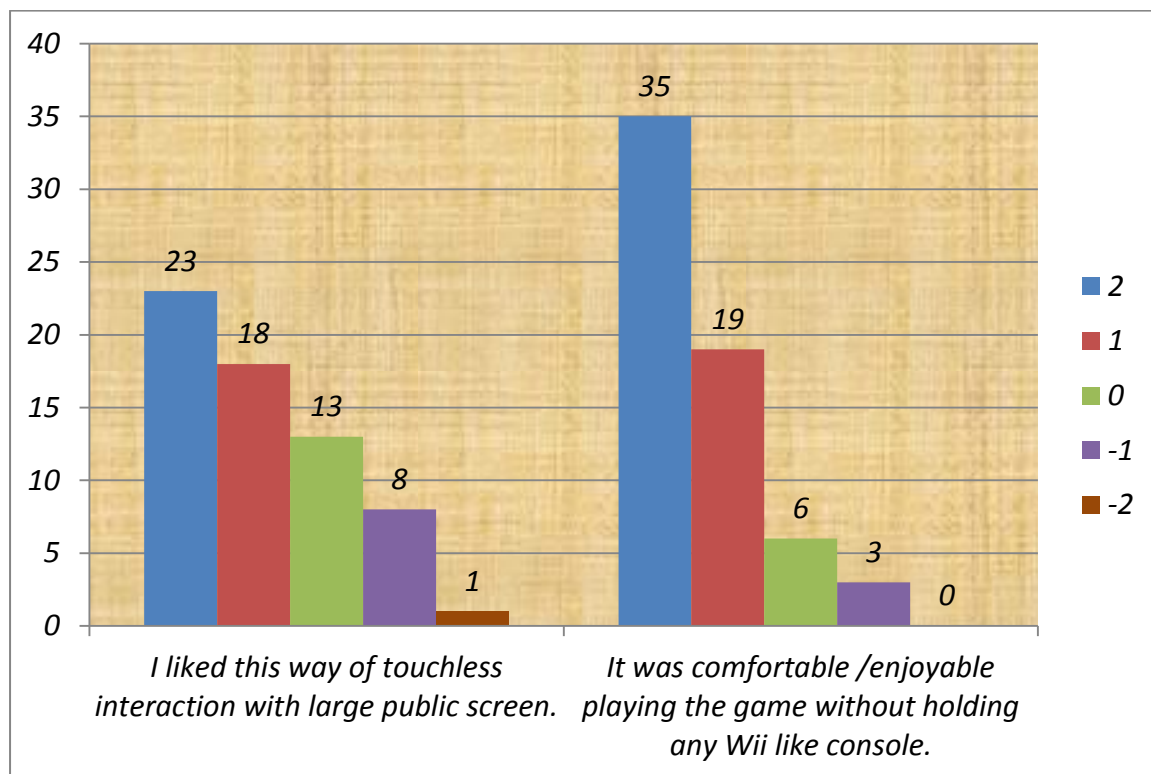
6.1.9 Touchless Interaction

Figure 18

❖ This feedback from the user plays an important role as it brings into consideration an entire new genre of interaction with computers and large screens in public space.

❖ Most players liked the touchless interaction with the large screen. Around 66% of the participants expressed their willingness of interacting in a touchless manner with the large screen. 14% conveyed that they did not like this manner of touchless interaction where 20% very not fully happy with it.

❖ Also most players revealed that it was confortable and they enjoyed playing the game without holding any console. About 86% of the participants acknowledged the above statement. 10% of the players expressed that it made no difference to them and 4% conveyed their discomfort interacting in this manner.

This is considered an important finding as to people like touchless interaction with large screens at the public space. This is will encourage designers to develop more innovative and interesting game in this genre. This was one of the important criteria for this research as well, which as be achieved.

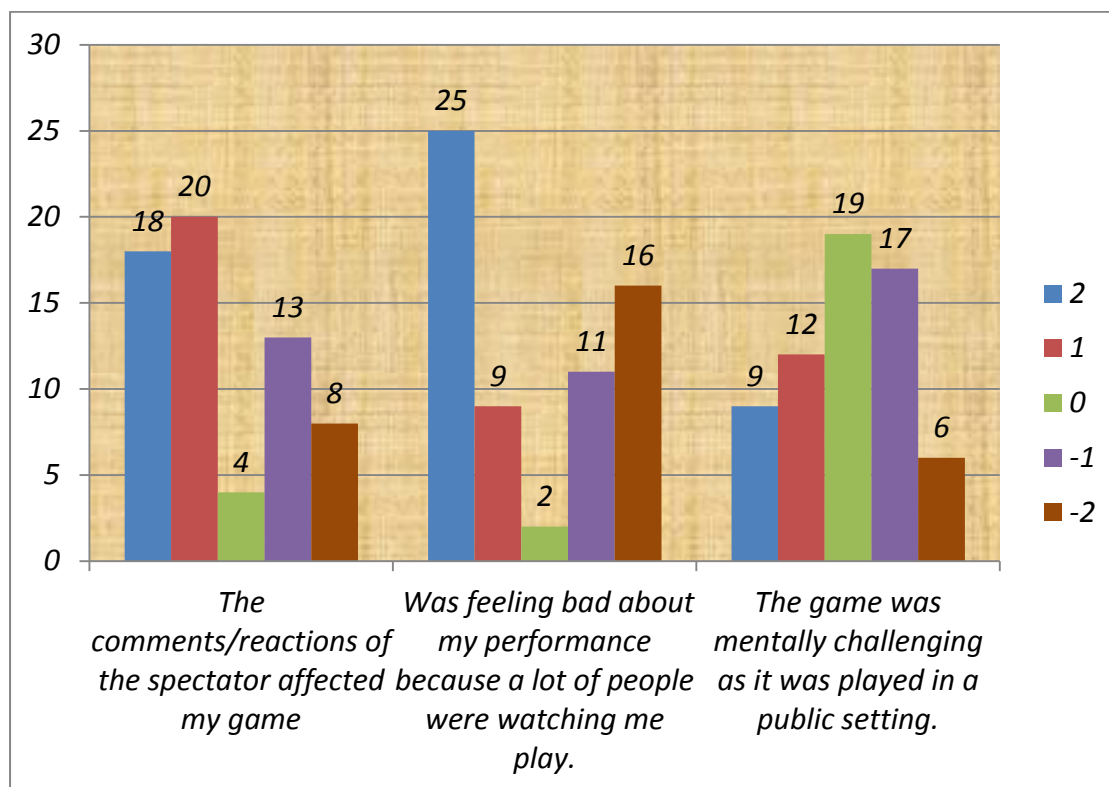## 6.1.10 Impact of public setting on the participant

Figure 19

This review provides a very important aspect of the research criteria. It gives the impact of public setting on the participant and the way it affected his/her game.

❖ Firstly large section of participants, about 61% expressed that the comments of the spectator had a significant impact on their performance. While personally interviewing them most players said that it had positive impact encouraging them to perform better. Whereas 33% of the participants said it made no impact on their performance.

❖ On the other hand, about 53% expressed that they were unhappy about their not so good performance because a crowd was watching them play. The good side of this is that it acts as motivating factor for the player to perform better and motivates them to exercise more.42% of the participants said they weren't worried about people watching.

❖ When asked if the game was mentally challenging, as in was the game setting haunting them in the back-drop in their mind when the player was playing the game affecting their moves, about 37% said No and 30% were not sure whereas 33% of the participants said Yes.

6.1.11 Social gaming & Overall Experience
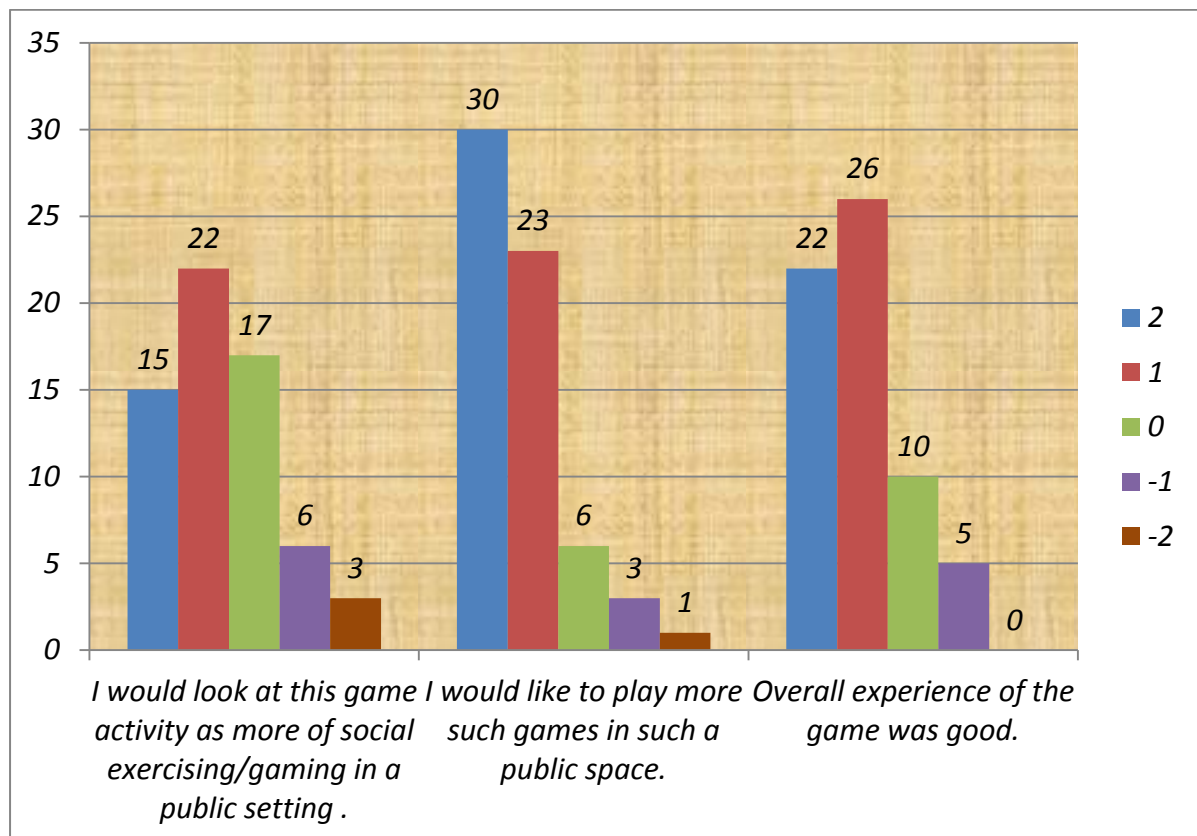
Figure 20

I wanted to get an opinion from the participants about a new and developing breed of gaming, the social gaming in public setting which could help to design and develop more game of such genre.

- ❖ When asked if this game was more of like a social gaming, 59% accepted that it was whereas 14% were not convinced and the remaining 27% where not sure.

- ❖ But the interesting fact was when asked if you would like to play more such exertion games touchless games in a public setting the response was overwhelming with almost 84% expressed their willingness with just 10% unsure and 6% expressed negatively. This is a great motivation to design game of social gaming genre.

- ❖ About 76% of the game participants rated the overall experience of the game as good whereas 16% rated as neither good nor bad and 8% expressed as not having a good experience.

6.2 Observations based on the interviews of the participants

Apart from the questionnaire the participants were also interviewed, with intensions to give them an opportunity to put across their feedback about the game & entire setting in a better and informal way. These questions were almost related to the questionnaire. Most of the participants expressed that they have been playing the traditional button - press computer games and video games and found a vast difference between the 2 games. Some of the spectators were also interviewed to get their opinion as well.

Most participants appreciated the idea of an exertion game in a public setting as one participant commented "This game is an amazing way to exercise, as running around is great way for exerting and it is also fun to play.". A lot of participants expresses that they wanted to play longer because it was fun but were unable because they were exhausted after playing a few games.

Large number of participants expressed that it was pleasurable and easy to play the game in a touchless manner with one of the participant commenting "Yeah I like the idea of the game, unlike Wii or Xbox, where you need to hold something in the hand, this game allows us to play freely."

Even though basic sound was played during the game, few participants suggested that it would great if some kind of leg-tapping music was played alongside game to set the mood of exercising in gym.

Another participant commented" Great way to make friends if you are new to town as it is an informal beginning to social bonding" .Most players also expressed that this game helped kick-start interaction between strangers in a public space. Most participants who were introvert seem comfortable with the other person with whom they played the

game during the interview and this was ascertained by the participants during the interview. Lot of participants also felt that there wouldn't be any change in the way they interacted even if they game was played in a non-public setting.

Most players articulated that this kind of game in public setting was fun to play and it was motivating as large crowd of unknown. One of the participant commented "It is more exciting and induces a spirit of competition when playing in front of large crowd." This is a great motivation for developing more game of social gaming genre.

One of the downside of the setting was most people were unable to decide or were not willing to participate in absence of compere. On the other hand more than 2/3 of the participants expressed the willingness and liking to play more such games in public space

Most player complained that the detecting the movements and the ball movement in the game was slow resulting in a slight arrhythmic display. This is due the hardware as we used slow camera (low frame-rate).

6.3 Summary

This chapter contained the various outcomes of the experiment. It accounted for results that showed experience of the players feeling the exertion during the game, enhanced liking of the exertion game by the participants and helping interaction between individuals in a public space. Interviews provided a peek into the potential of exertion games and also recommended the certain information for future social games.

7. DISCUSSION & CONCLUSION

7.1 Discussion

The aim of this thesis was to ascertain if existing Muller's framework for exertion game could be used to develop exertion game/physical activity for a public setting like an area in front of a shopping Mall or city centre and how this setting affects the collaborative play & interaction between strangers in such an environment. It was necessary to incorporate touchless interaction with the system. Any kind of interaction or a game that is coupled with physical activity will enable better communication among different people rather than traditional keyboard-mouse game. A game of like this nature which includes interaction along with an engaging physical activity will foster this kinship for further communication between participants. A questionnaire regarding exertion game in a public space revealed that these kinds of computer centric games gave an insight on individuals' physical fitness and also helped them in bonding together.

In order to test Muller's framework, I designed and developed a Human-Pong game. This game requires players to play a virtual ball game, with the game being played in a public setting on a large screen, and requires physical activity like running. The player playing the game doesn't have to hold any console as it implements touchless less interaction.

7.2 Experiment Outcomes & Finding's

The analysis on feedback based on the questionnaire divulged many statistically significant observations about the entire game including the setting. It was possible to derive at a conclusive decision based on feedback on all the significant aspects of the research.

❖ The main conclusions derived regarding exertion related

1. Most participants were experiencing heavy breathing or sweating or both giving them a sense of exertion.

2. Participants experienced exertion during playing the game which made them more fitness conscious and wanted to involve themselves in more of such social exertion games.

3. They liked the game and wanted play longer but were exhausted.

4. Most participants expressed that this kind of exertion (involving physical activity) computer game is more enjoyable and fun compared to the traditional button press computer game.

❖ The main conclusions derived regarding social interaction/social gaming

1. Participants mingled and knew each other better after the game.
2. The participants conveyed that the game by some means provided an opportunity for a highly substantial social bonding between them and also the spectators around the playing area.
3. They wanted to become friends with the other player.
4. The game helped participants as an Ice-breaker and resulting in having great conversation with other player and helping them understand one another much better.

❖ The main conclusions derived regarding collaborative play.

1. It was fun playing the game together and want more such games in public setting.
2. Playing a game in public setting motivated the players to perform better.

❖ The main conclusion derived regarding touchless interaction with large screens.

1. Participants overwhelming enjoyed this kind of touchless interaction with the large screen.

2. They enjoyed this kind of content to the large screens in urban environment.

All these factors made the overall experience of playing an exertion game in a public setting great.

With respect to Muller's framework, the above designed game satisfied all four lenses on the framework. The responding body and moving lenses gives inner perspective of the body in exertion and change in muscular position of body parts due to the exertion activity and this was evident from the game as most participants expressed that they experienced some kind of internal changes such as breathing heavier & sweating as a result of running around. This gave them sense of exertion which was the fundamental objective of the game.

From the sensing body lens, the player has to interact in touchless manner with the large screen just by performing an exertion activity like running which they said it was fun and comfortable. Players also conveyed that they co-ordinated & interacted with other player to play the game more efficiently and this resulted in social bonding which continued after the game.

Finally from the relating body lens viewpoint, since the game was played in a public setting the player had to perform in front of huge unknown audience this had some

positive and negative impact on his game. Most players were motivated to perform better and some felt bad about their dismal performance. It created a sense of social bonding between the player and the spectators.

The game designed on Muller's Framework for exertion games focus on all the aspects of the activity with the player experiencing an exertion activity to collaborative interaction among player during the game, which in turn helps them interact more friendly with each other after the game. In this we also focus on interacting in a touchless manner which received copious appreciations from the participants. Since this game satisfied all the research criteria and it was developed based on Mueller's framework for exertion game, it can concluded that this framework servers as bases for developing most exertion games.

7.3 Suggestion for Further Developments

This study exposed some unforeseen although appealing results. These results pooled with the opinions from the interviews, formed the basis for following suggestions necessary for the design of such exertion games for public setting with touchless interaction with large screens in the future.

- ❖ If implementing touchless interaction game use a high speed-high definition camera for detecting human movements. Also can use various techniques of Opencv like HISTOGRAM and CAMSHIFT to make image processing and detection faster than Haar classifiers which have been used in this system development.

- ❖ The game can be extended with networking capability so that it played by people in different cities which help increase a sense of competition.

- ❖ Include more exertion actions into the game like gesture detection.

- ❖ Develop game that can accommodate larger teams since it is more enjoyable.

- ❖ Add some rhythmic music to make the experience more enjoyable to the participants and the spectator.

7.4 Conclusion

This thesis has tested Mueller Exertion game framework, and has shown it can be used to design and implement games for public setting with included touchless interaction with large screens being valuable addition to the present technique for social interaction. The experiment demonstrated an activity which can be referred as a new genre calling it social exercising/gaming. The participants reported a significantly

dandier social bond between player and spectator when playing such exertion game in such a public setting. The participants also expressed that they had fun playing the game in a touchless manner and rated the overall experience as good.

In accession to an exertion activity in the implemented game, it also provides a new eccentric world of social gaming which is tailor made for social interactions with touchless interaction being expedient for a public setting. This technique looks in the antithetical direction to most of the present-day passively-interactive button-press computer games with minimum exertion activity involved. It also adds an element of zest as it is easy to play, difficult to master since it demands skill, strength and practice with public setting being added onus on the mind.

An exertion game on this genre in a public setting not only facilitates interaction between strangers but also gives a sense of fitness for the participants by adding an element of excitement with touchless interaction with the large screens, that proliferating our urban environment. This gives opportunity for developing new genre of game that facilitates social gaming. Mueller's framework can be used to develop these kinds of exertion games for public setting which can involve touchless interaction with large screens. This was an interesting and successful research of getting various aspects of computer Science, like HCI and touchless interaction in one single platform of social gaming.

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9. APPENDIX

9.1 Questionnaire – Collaborative Touchless Interaction game

Thanks for participating in the game. Please take a few moments to complete the below set of questions. This is an important element for writing my thesis. I 'm interested in your thoughts and opinions about the game and the entire setting. There is no such correct answer for any question just your opinion .You may find the process boring but do answer all the questions well thought out &in earnest. Please answer frankly as all the answers are completely confidential and will be used only for this research purpose. Kindly feel free to ask any queries.

❖ I'm

        Male □   Female □

❖ Year of Birth

        [   ]

❖ How many games did you play during the experiment

        [   ]

❖ How long did you play the game in the experiment (Including all the games).

        [   ]

Rating Scale for the below questions

   Strongly Agree = +2   Agree = +1   undecided = 0   Disagree = -1   Strongly Disagree = -2

❖ The other player did not seem friendly.

  +2□   +1□   0□   -1□   -2□

❖ I got to know the other player.

  +2□   +1□   0□   -1□   -2□

❖ I would like to exchange mobile number or email with address with the other player

  +2□   +1□   0□   -1□   -2□

❖ I remember who won most games.

  +2□   +1□   0□   -1□   -2□

❖ I wanted to play the game longer.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ I played the game more passionately and competitively than the other player.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ The result of the game didn't matter to me.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ The other player seems like a nice person.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ I would like to be friends with the other person.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ It was more like a social game/exercise than just a computer game.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ Had fun playing the game in such setting.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ I didn't interact with the other player during the game.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ The activity created some kind of social bonding with other player/spectators.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ I interacted a lot with the other player after the game.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ I liked playing together rather than playing against each other.

+2☐ +1☐ 0☐ -1☐ -2☐

❖ It was comfortable /enjoyable playing the game without holding any Wii like console.

+2☐ +1☐ 0☐ -1☐ -2☐

- ❖ The game was physically demanding.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ I would like to play more such games in such a public space.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ The comments/reactions of the spectator affected my game.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ Was feeling bad about my performance because a lot people where watching me play.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ After playing such a physical intense game it motivates me to involve in more physical activity(like sports or gym)

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ I would have played the game even without anyone initiating the participation.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ I liked this way of touchless interaction with large public screen.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ I got a sense of my fitness level after playing this game.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ I interacted a lot with the other player before the game.

  +2☐   +1☐   0☐   -1☐   -2☐
- ❖ I would look at this game as more of social exercising activity.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ The game was mentally challenging as it was played in a public setting.

  +2☐   +1☐   0☐   -1☐   -2☐

- ❖ Overall experience of the game was good.

  +2☐   +1☐   0☐   -1☐   -2☐

9.2 Some of the Questions asked while personally interviewing the participants.

1) Will there be any change in the way you interacted with the other player, if game was played in a different setting (as in a non-public space)? If so in what way?

2) How much did the setting affect your performance in the game and in what way? Would the way of your playing the game be different if game was played in a different setting (as in a non-public space)?

3) What is your opinion about such games in public setting as a way to exercise while you socialize?

4) If you wanted to play the game longer, why so and did you end up playing longer than you expected?

5) Did you like the idea and setting of the game? What is your opinion on various aspects of the game?

6) Would you like to suggest any changes?