Amit Patil

Digitally signed by Amit Patil
DN: cn=Amit Patil, o, ou, email=amitrpatil@gmail.com, c=IN
Date: 2010.04.13 18:33:08 +05'30'

Abstract

Interaction research has existed since ages by various names. Recently it has re-gained focus again with the advent of touch and gesture based technologies entering the off the shelf consumer goods.
From the GUI's to gesture based interactions gesture based technologies have evolved in various domains and fields. Hand gestures have found focus on in recent devices like gaming consoles.

The aim of my thesis was to explore this rising domain of gesture based interactions. The focus of the project was to find opportunities for gesture based interactions in the context of exploratory learning among kids.

The project initiates with understanding of the domain of gestures as a whole followed by further understanding of exploratory learning.
A user research to understand interactive behavior of children gives real world insights about the role of gesture based interactions in exploratory learning.
The project explores few interface issues related to gesture based interactions and interfaces.
Followed by domain and user research few concepts show the use of gesture based interaction for exploratory learning.

Out of the available pool of concepts few concepts are chosen and detailed.
A detailed design of one such concept is presented that shows application of gesture based interaction for exploratory learning.

The project concludes with the prototype of the design that displays a part of the possible implementation of the concept.

It is evident from this project that exploratory learning is a domain that can be benefit from gesture based interactions in future hence benefiting the children of the future.

Amit Patil

Digitally signed by Amit Patil
DN: cn=Amit Patil, o, ou, email=amitrpatil@gmail.com, c=IN
Date: 2010.04.13 18:33:31 +05'30'

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Amit Patil
Digitally signed by Amit Patil
DN: cn=Amit Patil, o, ou, email=amitrpatil@gmail.com, c=IN
Date: 2010.04.13 18:33:59 +05'30'

About National Institute of Design

The National Institute of Design (NID) is internationally acclaimed as one of the foremost multidisciplinary institutions in the field of design education, applied research, training, design consultancy services and outreach programmes. It has been the recipient of significant national and international awards since it was established in 1961 as an autonomous institution under the Ministry of Industry, now known as Ministry of Commerce & Industry, Government of India. NID has been a pioneer in industrial design education after Bauhaus and Ulm in Germany and is known for its pursuit of design excellence to make Designed in India , Made for the World a reality.

NID graduates have made a mark in key sectors of commerce, industry and social development by taking role of catalysts and through thought leadership. NID has been recognized as a Science and Industrial Research Organization by the Department of Science & Technology, Government of India.

About HP Labs, India

Amit Patil

Digitally signed by Amit Patil
DN: cn=Amit Patil, o, ou, email=amitrpatil@gmail.com, c=IN
Date: 2010.04.13 18:34:13 +05'30'

HP Labs is the exploratory and advanced research group for Hewlett-Packard. The lab has some 600 researchers in seven locations throughout the world.

HP Labs, India was established in February 2002 with the principal focus on creating new technologies for addressing the IT needs of the next billion customers for HP. A large majority of these new customers arise from rapidly growing markets such as India with distinct technological, social and economic characteristics. By understanding this context deeply, HP Labs aims to create new and relevant technologies.

HP Labs India follows the tradition of deep technical research that has direct impact on HP's business through innovations in product and service offerings valued by customers.

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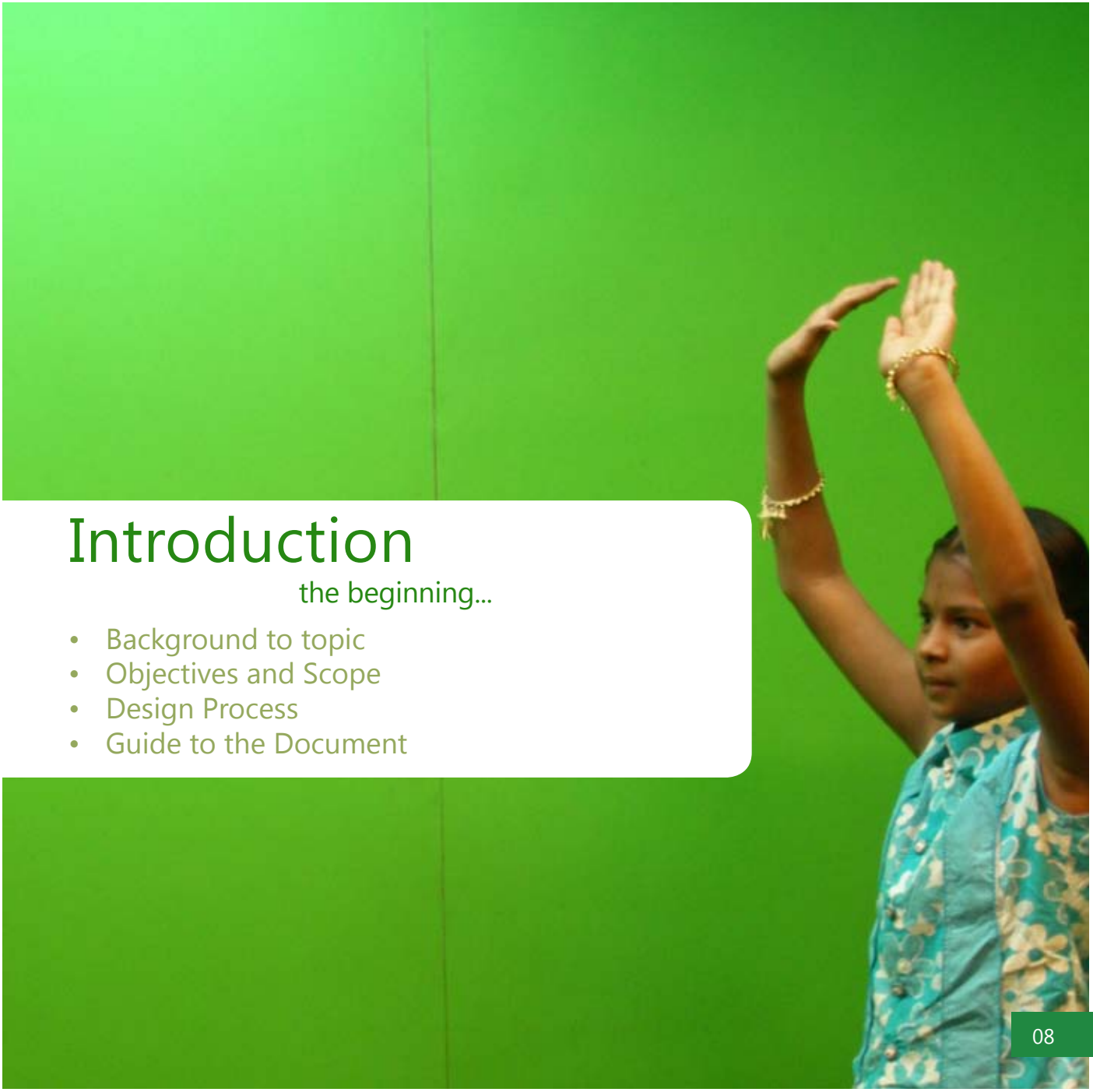


Introduction

the beginning...

- Background to topic
- Objectives and Scope
- Design Process
- Guide to the Document

1.1 Background to the topic

"Thinking is the deliberate exploration of experience for a purpose"
- Edward de Bono

Human mind has been thinking for millions of years in search of answers to a plethora of questions to lead a better life. In the urge to find the right answers, we humans create thousands of artifacts that evolve within our lifecycle with us. Some rise some fall, some survive the challenges of time while some wither with the hardships of chance. But we keep evolving and so do these artifacts within our lifestyle.

The saga of technology has been a catalyst for the evolution of artifacts in the past era. During its initial efforts, technology changed mankind to adapt to it but as we move ahead in time the future withholds some new miracles. We see a revolution in technology is slowly evolving towards technology that adapts to mankind.

From the early days of buttons and switches computers as artifacts have evolved tremendously. With a focus on interaction today we see the rapid adaptation of the way we interact with our computing devices and artifacts.

The future awaits the rise of new interaction techniques to evolve, which are more natural, easy to learn and do not require the users to adapt to them, but adapts to the users needs and behaviors.

The design of gesture based interactions techniques has been one such effort in the race to make technology more human friendly.
Right from childhood gestures are an integral part of humans. However technology has not been able to completely exploit this facet of human characteristic.

As we move towards more human centric technology we can see experiments along the lines of face voice and gesture recognition around the world.
Using these technologies to design interactions that benefit more natural and intuitive interactions seems to be the challenge of the future.

The ***project explores the challenges and opportunities in the domain of designing gesture based interactions*** for desktop computing devices.

^ Interactions need to be upgraded like interfaces have.

Amit Patil
Digitally signed by Amit Patil
DN: cn=Amit Patil, o, ou, email=amitrpatil@gmail.com, c=IN
Date: 2010.04.13 18:34:35 +05'30'

1.2 Objectives and Scope

Aims and Objectives

The broad aim of the project is exploring opportunities for gesture based interaction techniques.
It focuses on identifying and designing gesture based interactions that allow exploratory learning activities for kids.

The key objective was to design gesture based interaction techniques for existing or new desktop applications that allow exploratory learning for kids.

Scope and Constraints

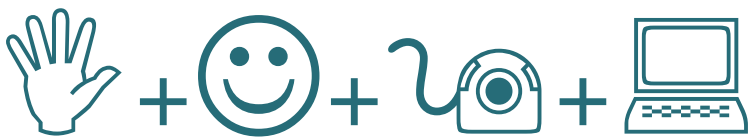
Certain project constraints were identified to define the scope of the project as follows:

1. Gestures indicate hand gestures.

2. Kids indicate kids from an age group 11 to 14 i.e. early adolescence.

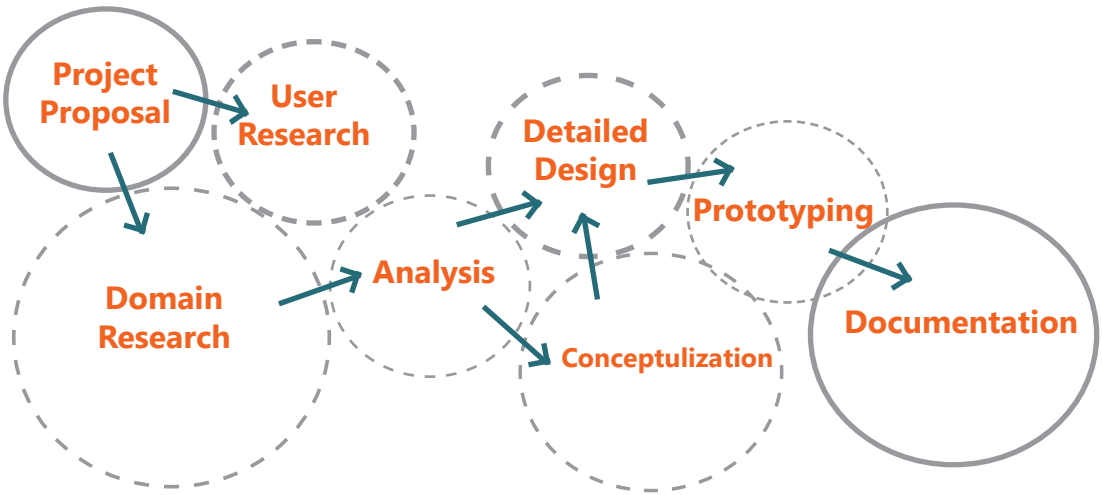
3. Gestures will be recognized using camera (preferably web camera).

4. Desktop PC will be the primary device on which the interactions will be performed. The secondary can be laptops with cameras.



1.3 Design Process

Interaction Design (ID) is an emerging field in the domains of design. However it is not new and designers have been designing interactions since long, perhaps in present era it has got more recognition from other fields.
Considering the standard User centered approach, the design process that was followed for the project was as follows:



The project started by defining the rough scope and framework of the project.
The user group was selected followed by user research related to the topic.
A domain research was done simultaneously which continued across the project. Using the understanding of the initial research, concepts were built to reflect the findings. These concepts were reviewed across experts. Based on the feedback and the feasibility they were modified and improved to pick up a final concept. The final concept was detailed.
Simultaneously the detailed concept was prototyped.
Documentation of the process was done in parallel to keep track of the project.

1.4 Guide to rest of document

The document is divided into nine sections. Considering the design process followed the document flows accordingly.
The nine sections can be further seen in two broadlevel sections. The Research Section and the Design Section.

The Research section explains the information and expertise collected to proceed towards design, on the other hand the Design section showcases the application of the available information consciosly or subconsciosly towards the focus of the project.

The project being exploratory in nature gives equal weightage to Research and to Design. Research Section consists of chapters 1 to 6. While chapters 7 onwards Design of the project is discussed.

Chapter 1: Introduction
The chapter that you currently read gave a brief outlook of the project scope and dimensions.

Chapter 2: Designing Interactions
The next chapter gives an idea of the difference between design of interactions as against interfaces.

Chapter 3: Inspirations and Intentions
A bit philosophical this chapter explains the bigger influences on the project. It also explains the ideological intention behind the project.

Chapter 4: Domain Research
Introducing the domain area of the project this chapter elicitates the know how of gestures, exploration and gesture based technology. It consists of secondary research regarding this area and its understanding.

Chapter 5: User Research
Followed by the Domain Research this chapter talks about the specific user research undertaken for this particular project. After the initial observations the chapter concludes with the analysis of the observations via numerous and insights and design principles that are generated.

Chapter 6: Understanding Gestures'
This chapter is an extention to analysis of domain and user research. It reflects about the basic understanding of gesture based interfaces and interactions in a broader sense. It states few issues and metaphors specific to the domain area.

Chapter 7: Conceptulization
The chapter marks the begining of the creative synthesis and intuitive generation of ideas for design. The chapter showcases the design concepts and the selection of the final concept.

Chapter 8. Detailed Design
The detailed design of the final selected concept in chapter 7 is explained in this chapter. The scenarios, personas and the implementation possibilities are discussed in the chapte. The chapter also gives the final

interaction scenario, which is the work product of the project.

Chapter 9: Prototyping

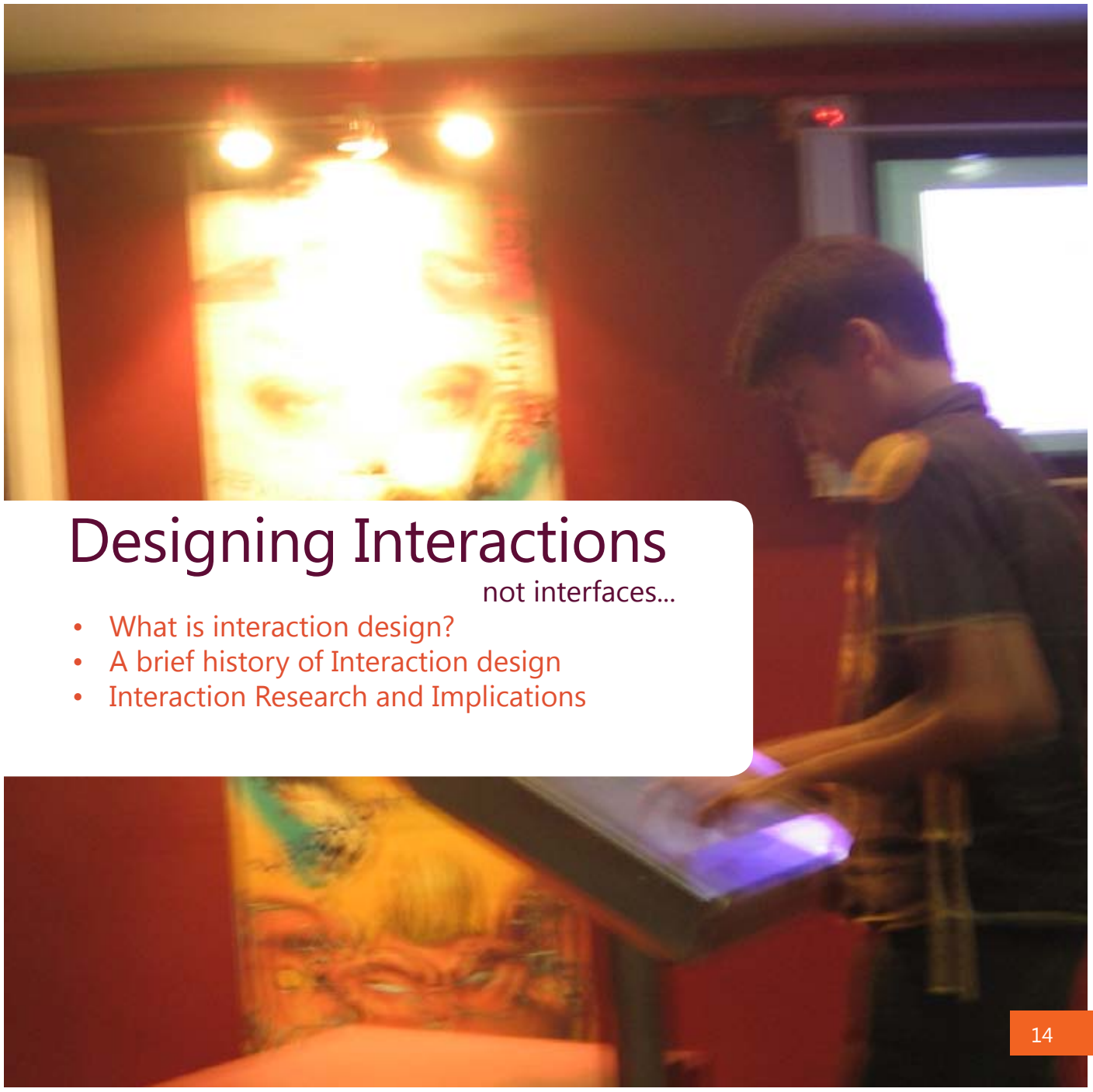
The chapter explains the implementation of the detailed concept of the project. The chapter also gives some technical details regarding prototyping of the concept. It explains the constructed prototype and possibilities for the improvement of the same.

Chapter 10. Conclusions and Learning

The final chapter of the documentation, it concludes the work done in this project and my learnings in the process of the diploma project.

Followed by the conclusion the appendix and the refrences give further links to the project.

The purpose of the document is to inform the reader about the six months Diploma Project undertakenby me as a part of academics under National Institute of Design. It acts as a medium to share knowledge to those who shall evaluate the performance during the period as well as those who can consider refering this work for any similar projects in near future.



Designing Interactions

not interfaces...

- What is interaction design?
- A brief history of Interaction design
- Interaction Research and Implications

2.1 What is Interaction Design?

We live in a world of countless objects and countless experiences. From the very moment that we step into this world we start interacting with something or the other. As we walk down the road. Laze in our offices. Survive our colleges or rest in our cozy homes, every little environment that we exist in we INTERACT.
Each one of the object that we interact with from morning to night or from birth to death has a behavior. Or each one of the object that we want response from has an innate property of its own which makes it react or act to us or our actions.
As far as all the humans concerned around us we can agree that each one of us behaves in a specific manner for specific instances. Dad scolds when you spend too much money, mom cuddles when you cry, dog barks when u step on his tail and the list goes on. Similar is the case with all the objects that we interact with. Taps open clockwise and close anticlockwise, buttons turn on or off, ipod pauses when button is pressed etc.
But there is a difference between the above two behavior types. In the former case we interact with living beings which have a behavior, while in the later case the objects that exist in our environment are not living, they are designed. And so are their behaviors.

"process of designing behaviors of every object that is intended to be used by humans is called- INTERACTION DESIGN."

This process of designing the behaviors of every object that is intended to be used by humans is called INTERACTION DESIGN.
But then we don't just design objects, do we?
As humans we design processes and environments also. Each of these also has their behaviors. Hence interaction design is not restricted to mere objects or products but also extends to services.

< Interaction design is the design of objects that helps humans communicate with the world.

The Interaction Design Association (IXDA) [1] defines Interaction Design as:

Interaction design (IxD) is the branch of user experience design that illuminates the relationship between people and the interactive products they use. While interaction design has a firm foundation in the theory, practice, and methodology of traditional user interface design, its focus is on defining the complex dialogues that occur between people and interactive devices of many types—from computers to mobile communications devices to appliances.

In short

Interaction design defines the structure and behaviors of interactive products and services and user interactions with those products and services

Although IxDA specifies a definitions there are still many other interpretations of Interaction design [2]. However what matters is that with evolving understanding of the field its application should benefit mankind towards a better present and future.

Interaction Design defines the behaviors of interactive products and services>

2.2 A Brief History in Time

At its most general level interaction design can be traced back to 2.6 million years of the early Stone Age when humans made tools out of stone. Each of these tools had specific shapes like handles etc which would enable ease of use.
However if we come to the evolution of interaction design in the technological era we can start with the "Push Button" [3]. Let's peep into a short history of some of the key phases of interaction design in the field of technology here.

1887

TELEPHONE PUSH BUTTON
Around in 1887 telephone push buttons were in research. An excerpt from the London Times March 9, 1887clearly specifies the awe

1890

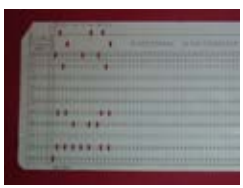
KODAK "CLICK"
George Eastman at Kodak introduced the 'Push to Click' interaction in 1890's. With their slogan "you press the button, we do the rest,"

1930-40

RADIO-TV BUTTONS
With the advent of radio and television around 1930's buttons made life easy. At the push or roll of a button you could see and hear things. Mapping of roll buttons to tuning linear stations may have been one of the interaction researches in that era.

1940-50

ENIACS/ PUNCH CARDS/DEC-PDP
ENIACS which were interacted with punch cards Punch cards were more or less designed as per the machine in perspective. And the interaction part of the punch cards was not predefined but strict rules like "Do not fold, spindle, or mutilate"[8] were specified explicitly.



1956

THE REMOTE CONTROL
Buttons go Mobile.The concept of remote control was first conceptualized by Nikolas Tesla back in 1893; the Zenith Radio Corporation in 1956 was the first push button remote company with a mobile push button named "Zenith Commander".

SPACE WARS:FIRST VIDEO GAME

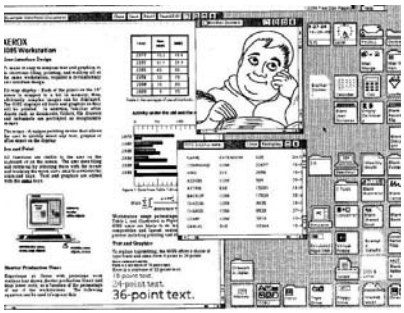
Steve "Slug" Russell, a young computer programmer out of Dartmouth led a team of programmers at MIT, who created the first computer video game, "SpaceWar!"

1962-63

1963-68

SKETCHPAD/ MOUSE

Sketchpad [12] was a computer program that allowed interacting with the computer to draw on it. The mouse could click on different objects and was by far the best demo in computing history. The mouse also had a button which showed the regeneration of the button from the beginning.



1979

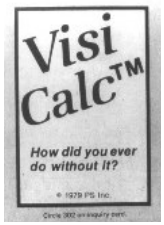
XEROX STAR: GUI REVOLUTION

Xerox Star allowed applications to be loaded and realized. The Xerox Star 8010 Document Processor was released to the public in 1981 for US$17,000.

1970

VISICALC: INTERACTIVE SOFTWARE

Sketchpad [12] was a computer program that . VisiCalc was the first spreadsheet program available for personal computers. It may well be the application that turned the microcomputer from a hobby for computer enthusiasts into a serious business tool.



1983-90

MOBILE PHONE INTERACTION

Motorola DynaTAC was the first mobile phone launched within the mist of software and personal computing wars.NTT DoCoMo had built mobile phones much before Motorola and created a huge market by then. Mobile phones became a common device and companies like sony, nokia entered the market with experiments with the interface and the interactions.

1998- 2000

INTERNET

The internet revolution gave new interaction paradigms beyond desktop metaphors. The connectivity of the internet gave a perspective of human to human interaction over the networks. Emails, chats, video conferences were the new generations of communications.

2006-07

SURFACE/ IPHONE/ WII

Jeff Han demonstrated the MultiTouch Table at the TED conference. The way we interact with virtual objects further changed bringing out new possibilities. Nintendo launched Wii, its gesture based gaming console. Microsoft lauched Multitouch table surface. Apple launched multitouch on the iPhone.

2.3 Interaction research and implications

Design is viewed as a unique way to look at the human condition, and is understood through reflective practice, intellectual apperception, and intentional choice. There is a growing interest in research aimed at supporting design.
Design Research has emerged slowly across the industry with varied definitions.
In the HCI community and in the design practice community, the term design research is generally used to refer to the upfront research practitioners do to ground, inform, and inspire their product development process. However, in the design research community, including institutions such as the Design Research Society [16], the term design research implies an inquiry focused on producing a contribution of knowledge.

Off late Interaction research has evolved with good impetus on the interaction of the products. A study of human behavior to understand the way they interact with real and virtual objects has helped designing more user friendly products [17].

Interaction design as a field is slowly getting an identity and experts in the field think [19] that there is a need to develop and foster new designerly approach for education and practice.

There are many existing works produced by contemptary design thinkers which has not been fully explored and exploited in relation to potential value it can bring about.

The process for conducting an interaction research has largely been intuitive in the design community; however few models [18] give a brief idea of possible methods.
The difference in scientific methods verses design methods for interaction research also needs to be understood for better insights [19].
There also seems to be an important issue in understanding ways to evaluate interaction research. Few Models [18] suggest Process, Invention, relevance and extensibility as metrics to evaluate the research.
Future of HCI Research [21] can look around new methods in HCI as well as more collaborative approach with other communities.

Interaction research is fast growing and it seems that with the semantic shift of technology towards valuing human experience it has great potential to inform the evolutionary process for a better tomorrow.

^Nokia Sensor, a research based mobile software allows users to detect other users who are in the vicinity and communicate.

Intentions & Inspirations

the hidden motivation...

- Inspirations
- Interactions for Human Augmentation
- Intentions

3. 1 Inspirations

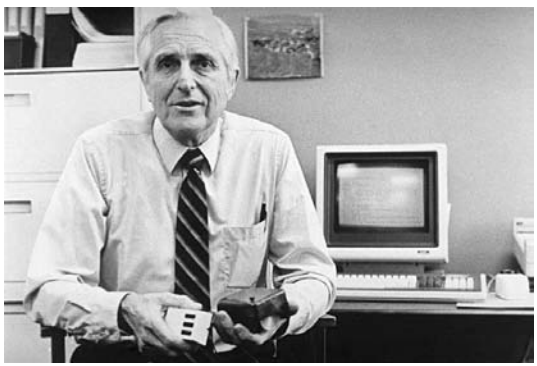
"On December 9, 1968, a young scientist and the group of 17 researchers working with him in the Augmentation Research Center at Stanford Research Institute in Menlo Park, CA, presented a 90-minute live public demonstration.
This demonstration changed the way the world worked and lived in the future."

The young scientist mentioned above is none other than the inventor of mouse Dougles C. Engelbart. This was one of the most path breaking demos of computing history and was the public debut of the computer mouse. But the mouse was only one of many innovations demonstrated that day, including hypertext, object addressing and dynamic file linking, as well as shared-screen collaboration involving two persons at different sites communicating over a network with audio and video interface.

However the research that gave birth to these inventions was based on a conceptual framework called Augmenting Human Intellect [22].

In his paper Engelbart proposed conceptual framework that enables the role of tools, methods and concepts to augment human intellect so that humans can make better decisions in the fast becoming complex world.
One of the tools was the computer which can be harnessed for varied activities to make the human more intelligent

From the deeply interesting theory of Engelbart what can be clearly seen is the focus on development of tools, methods and concepts to augment human intellect.
By augmentation he meant the extension to human capability. He believed that humans have been evolving beyond their basic capabilities so that they can derive comprehension from truly complex situations and accomplish the process of deriving and implementing problem solutions.



<Douglas Engelbarts' with his invention the mouse

3.2 Interactions for Human Augmentation

In my design thesis I would like to take forward the ingenious thought process of Engelbart, who without argument can be considered the father of modern day technological interaction design.
In his paper Engelbart demonstrated the design of certain techniques and artifacts that enable augmentation.
What I would like to propose is the design of new interaction techniques which help in human augmentation.

Here I mean that while designing "interaction techniques" we can design them in such a manner that it improves the current state of the human, not to make him addicted to the system but to be better while making decisions when he goes to the outside world. When designing new interaction techniques, the techniques themselves must be such that it enhances the human intellect.

Human Augmentation here means to help the people observe, think, understand and decide in day to day life in a better manner.
It should however not be compared to vitamin pills or steroids that make the person strong without any other parallel activity.
Augmentation with interactions here is about becoming part of human ecology to make him decide, act or react in a much better manner in the real world.

"Human Augmenting here means to help the people observe, think, understand and decide in day to day life in a better manner"

Today augmentation has evolved all across us as we see the fruits of technology helping us at every turn of our life. The Internet informs us and keeps us updated with passing time. The Mobile and networking technology has connected thousands of us which helps us make our everyday decision making.
If we talk about augmentation implicitly many interactions exist in training module to repeat specific tasks.
For example car or flight simulators or demo software's or games.

The augmentation dealt with here however is not just the physical augmentation but also cognitive augmentation like: Quick decision making. Increase in thinking and understanding capability Etc.

3.3 Intentions

Augmenting human intellect has been attempted in many ways till date. Each one of them has contributed to the humankind in their own way.
In the given constraints and the limited design skill sets that I posses the project aims at understanding the application of gestures for human augmentation.

Gestures have been an implicit part of human lifestyle ever since Prehistoric Times [23].And their very usage among humans shows the implicit origins of human language. Recent research [24] has shown that gestures help in learning among kids. Applying such practices the project seeks understanding in the role of gestures in human augmentation.

Exploration is one of the basic activities of all living beings. All living beings explore wither for food, procreation or survival.

As the complex human brain evolves his exploratory needs have also evolved.
Adding to humankinds cognitive needs of exploration to know or create has been representative of the fact that curiosity is one of the inseparable parts of human behavior.

Considering the importance and relevance of the above two topics under the umbrella of the human augmentation theory [22]

"The project intends to understand the role of gesture based interaction technology in exploratory behaviors."

The explicit usage of gesture based interaction to augment the human capabilities of exploration becomes the focus of the project.

Domain Research

understanding the domain...

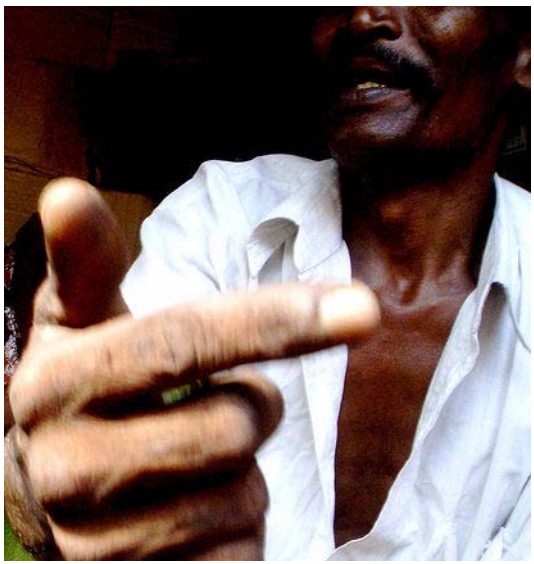
- Gestures
- Exploration
- Exploratory learning
- Gesture based interactions

4.1 Gestures

What are gestures?

Clap, Snap, Slap, Wave, Push, shake, Cheer gestures are all around us and we use human body in so many varied ways to communicate intentionally or unintentionally.

In everyday discussion we all know what we mean by 'gesture.'
Gestures are an integral part of us humans and have been around even before



"An action performed to convey one's feelings or intentions."

language evolved [Susan Meadow].
As humans we make new meanings everyday to communicate with the world. And as we communicate, gestures become a part of process.
However we need to define gestures to further understand its associations.

The oxford English dictionary defines gestures as

Gesture: noun
1. A movement of part of the body to express an idea or meaning.
2. An action performed to convey one's feelings or intentions.
3. An action performed for show in the knowledge that it will have no effect.

We can consider the second meaning in our context where an action is performed to convey one's feelings or intentions.
This action may be using our body or an external device to indicate our feelings or our intentions to do an act.

^Mime is the best example that shows role of gestures in communication.

Gestures and their associations

Gestures have been studied since ages [25,26] with a purpose to know their role or significance in human life. Across domains from Arts to sociology to science, psychology and semiotics gestures have been looked upon from different perspectives. The closest association by far has been communication since it's a natural outcome of human emotion and expression. Each one of us gesture in some or the other way and this is true across regions, countries and cultures.
However gestures change their meanings across cultures and traditions [27] too

Gestures and Communication

Human communication is generally associated with speech however non verbal gestures play an important role in any type of communications. The gestures that are most salient to speakers, and to listeners, are the codified (or conventionalized) forms that can substitute for speech.

Speakers routinely gesture with their hands when they talk, and those gestures often convey information not found anywhere in their speech. This information is typically not consciously accessible, yet it provides an early sign that the speaker is ready to learn a particular task [28].
When speech is inaccessible gestures become essential.

Sign language is another instance where gestures and communication has evolved. These gestures are mostly learnt gestures as against natural ones.
Speech and sign languages are generally close however some differences exist.
Sign Languages depend on the spatial contrasts while speech is linear and non spatial.
Many games like dumb-charades show the communicative power of gestures.
Gestures can then be easily differentiated into gestures with speech and without speech while communication occurs.

Gestures and Thoughts

Human Gestures are closely linked to our thoughts. And many times few experts [29] have deduced set patterns to identify the state of mind with just gestures.

The purpose of gesture has been seen to fuel the thought and speech as against just supporting communication. They are considered as objects of cognitive inhabitance and agents of social interaction. This means that gestures, the actual motion of gesture itself is a dimension of meaning and hence an extension to thought. [30]

Gestures also convey substantive information about a child's thoughts to ordinary listeners. The gestures that spontaneously occur in communicative contexts have been shown to offer insight into a child's thoughts. The information gesture conveys about what is on a child's mind will, of course, only be accessible to a communication partner if that partner can interpret gesture.[31]

Ancient Indian science of Yoga also claims the direct effect of yogic gestures on human mind. Mudras as they are called claim to help mental and physical abnormalities and hence cleanse thoughts and mind. These gestures have been used for medication for many years now. [32]

^Gestures and learning

Gestures and Learning

Gestures are often used in teaching and children are likely to profit from instruction when given with gestures as against without them.
Recent research [33] [34] proves that gestures can improve learning.
It has been found that representational gestures play an important role to teach a concrete quantity concept.
A number of studies also show that gestures can help with language acquisition. A gesture based technique can help in learning second language. [35]
Gestures are observed in teaching many topics like mathematical concepts, moral reasoning, and control of variables and rate of change.
In addition teachers and students often produce gestures during classroom interaction. Whenever an individual explains their own concept gesture is produced. [35]

Hence it's evident that gestures play an important role in learning.

Gestures and thought^

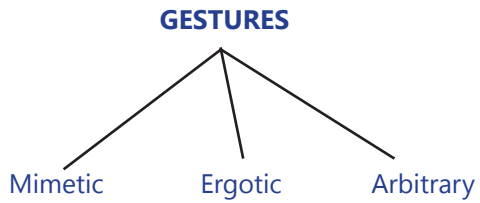
Gesture Classification

Classification helps in understanding a brief structure of any vast field like gestures in our case.
Since gestures have been studied in different domains for different purposes their classifications have been different.

One of the standard gesture classification schemes uses three categories: arbitrary, mimetic, and deictic [36].

In mimetic gestures, motions form an object's main shape or representative feature. For instance, a chin sweeping gesture can be used to represent a goat by alluding to its beard. These gestures are intended to be transparent. Mimetic gestures are useful in gesture language representations.

Basic Gesture Classification >



Deictic gestures are used to point at important objects, and each gesture is transparent within its given context.
These gestures can be specific, general, or functional.
Specific gestures refer to one object.
General gestures refer to a class of objects.
Functional gestures represent intentions, such as pointing to a chair to ask for permission to sit. Deictic gestures are also useful in gesture language representations.

Arbitrary gestures are those whose interpretation must be learned due to their opacity. Although they are not common in a cultural setting, once learned they can be used and understood without any complimentary verbal information. An example is the set of gestures used for crane operation. Arbitrary gestures are useful because they can be specifically created for use in device control. These gesture types are already arbitrarily defined and understood without any additional verbal information.

There have been few classifications of gestures according to their functions[37]:

a. semiotic: to communicate meaningful information and results from shared cultural experience. For example joining two hands for Namaste/ Greeting.

b. ergotic: is associated with the notion of work and the capacity of humans to manipulate the physical world, create artifacts . For example cutting using a scissor or breaking using hammer.

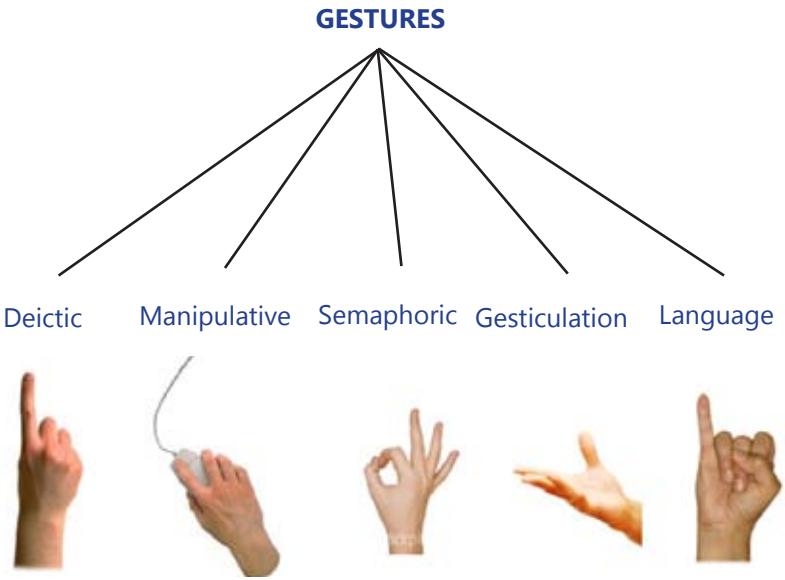
c. epistemic: allows humans to learn from the environment through tactile experience or haptic exploration. For example poking or feeling or touching.

There are many others who have classified gestures in different domains.
Maria Karam, student of university of southampton, in her PHD thesis: A framework for research and design of gesture-based human computer interactions.[38] has done a comprehensive study of the gesture classifications and has come out with a common gesture classification. This classification seems to be the closest to the domain of this project and hence considered hereafter.

Gestures can be divided into 5 major categories:

1. Deictic gestures
2. Manipulative Gestures
3. Semaphoric Gestures
4. Gesticulation
5. Language Gestures

Detailed Gesture Classification for HCI.V



^Deictic Gestures involve Pointing

1. Deictic Gestures

Deictic gestures involve pointing to establish the identity or spatial location of an object. Few instances of deictic gestures are as follows:
1. How do I go up?
2. That was the location where I started
3. He went in that direction
4. You can find some restaurants there
5. Last year I tried to do a similar thing

However the object does not have to be real or existent always while doing a deictic gesture, there are many instances when we point at non existential spaces while communicating for example we may point at a location saying "get out" however 'out' in this case would not mean any specific location.
In general Pointing is a good example of deictic gestures.

2. Manipulative Gestures

Applying a tight relationship between the actual movements of the gesturing hand/ arm with the entity being manipulated can be considered as manipulative gestures.

A good metaphor to understand manipulative gestures can be playing with shadow. A shadow is directly manipulated by our hands or body, as we move our hands our body the shadow also moves. A puppet is also a good example of manipulative gesture where few strings help us manipulate the body of the puppet.

The motion of the mouse with the onscreen pointer is a good example of Direct Manipulative Gestures. In case of which we manipulate the mouse which in turn manipulates the on screen pointer.
When the mapping of the gesture is directly mapped with the representation or entity that is mapped in time and space the process is called direct manipulation.

While the former can be considered as manipulation of the real the later is the manipulation of the virtual.

Manipulative gestures can be further distributed into more types:

a. 2D manipulations
b. 3D manipulations
c. Tangible gestures and digital objects
d. Tangible gestures and physical objects

a. 2D manipulations:
Gestures are generally 3D in nature because we live in a 3D world. However the effect of the gestures can be 2D in nature hence the gestures are then modified to balance the

2Dness of the output.
When the output of the manipulative gestures is 2D, then such manipulative gestures can be called 2D manipulative gestures.

A good example of such gestures can be the mouse again which allows manipulation of the pointer on a 2D screen. If we consider mapping, the gestures that we perform on the mouse are mapped to the position of the onscreen representation of the pointer.
b. 3D manipulations:
When a 3D object is manipulated using 3D gestures they can be considered as 3D manipulative gestures.
A good example for this can be use of hand gloves to manipulate a far away 3D object or a virtual object. The aspects such as pressure, weight or velocity need to be considered more in case of 3D gestures.

c. Tangible gestures and digital objects:
A further classification can be considered with tangible gestures that manipulate digital objects. So when you interact with a tangible object to manipulate a digital object it can be considered as tangible gestures.

An example for this can be motion of a chess piece in real world to move the simulation of the chess piece in the virtual world.

d. Tangible gestures and real objects:
In case of real object manipulation remote gestures have been effective. An example like moving a real hand in turn moves a robotic arm can be considered under this classification.
This is very close to magicians moving objects without being in physical contact with the objects.

3. Semaphoric/ Semantic gestures
Semaphores are certain flag signals that indicate a fixed message.
Semaphores are systems of signaling using flags, lights or arms [Brittanica.com].
In broader sense these are gestures which have predefined meanings. They can be done with using props (flags etc) or with bare hands.
So in general Semaphoric gestures or more rightly called semantic gestures are those that have a fixed meaning. These gestures may also vary culturally or regionally or even system to system.

These gestures can be further divided as:
a. Static or dynamic
b. Stroke gestures

a. Static or dynamic gestures
Gestures can be static or dynamic depending on the motion of the hands.

^Puppets are a good example of Manipulative gestures

Static gestures are those where there is no motion of the hands present and the static image formation of the hands denotes a message.
Some examples of static gestures are:
Thumbs up indicating positive or correct
Joining thumb and forefinger to communicate OK
Gestures where body motion in a specific pattern indicates a meaning are called dynamic gestures.

Some examples of dynamic gestures are:
Waving of hand indicates a goodbye or sometimes hello.
Motion of head can indicate affirmative or negative.

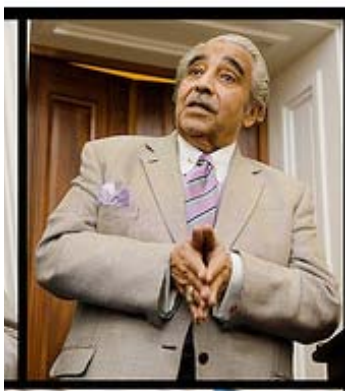
b. Stroke Gestures:
Stroke gestures can be considered as another type of semaphoric gestures.
The closest metaphors can be pen strokes or brush strokes.
Stroke gestures can also be called directional gestures as they start from a point and may move in a specific direction, just like drawing a line.

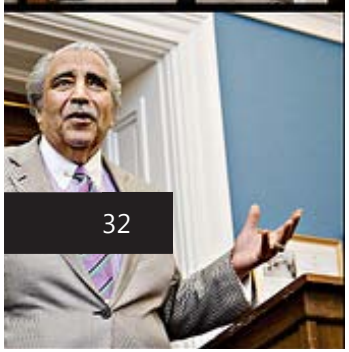
Some examples of Stroke gestures are:
Stroking the mouse back and forth to command an action
Flicking a picture in a specific direction

4. Gesticulations
Originally referred as co-verbal gestures there are gestures we produce naturally and may or may not have explicit implied meaning while performing the gesture or while interpreting.
For example we move our hands while we speak on a mobile phone.
Hand motion in public speaking can also be considered as gesticulation.
As discussed [Gestures and their associations] above gesticulations have been associated to expression and betterment of human mind.

5. Language Gestures:
Although very close to semaphoric gestures, sign languages are generally classified separately due to their direct relation to language as against other semaphoric gestures.
Some examples of language gestures are

1. Sign languages for deaf and dumb
Although seen as classified separately each of these types are not isolated and many times they occur in mixed context.





4.2 Exploration and Exploratory Learning

Exploration is the activity of finding out new things from objects and environment. Such an environment can be internal as you explore within yourself or external as you explore the world around you.

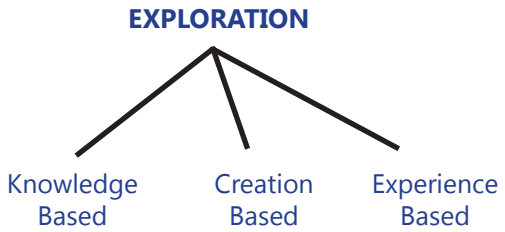
Traditionally exploration has been linked to traveling to new places. If we relate exploration to Space research exploration is about finding new things about the space. However exploration exists in all fields and deals with a process of knowing, creating or feeling the unknown.
The process of exploration is seen as a precursor to playful behavior. Through exploration the unfamiliar becomes familiar and it is then that play occurs [41].

In short when we do the act of exploration we find out new things.

Exploration types

Exploration can be of many types depending on the area of exploration however if we classify exploration separately we can divide it in three major categories:
Knowledge Based, Creation Based and Experience Based.

"...Through exploration the unfamiliar becomes familiar"



1. Knowledge based Exploration: To Know

In this type you explore to know more about particular things in your environment or particular things about objects.
The final understanding is the one that suffices as the discovery of this type of exploration.

Various Books Help us explore into different domains to know more about thingsV

^LEGO sets allow infinite possibilities to explore and create.

We can further divide this type of exploration in intrinsic or extrinsic as we try to know ourselves (imploration) or the environment (including the objects in the environment) around us.

An example of this is 'exploratory research' where we try to know about a particular domain or topic in-depth. This is generally done by looking around the available knowledge and understanding the same to make new meanings.

2. Creation based Exploration: To Create

In this type you start thinking of all possible available options. You create by combining what you can see hear or have. The core idea is to create as much as possible irrespective of which one is nice, right or wrong. Such an exploration can be called as creative exploration.
The creation is the one that suffices as the discovery of this type of exploration.

An example of this can be concept sketching of a car. You can keep sketching all possible forms that come to your mind. Here u take many variables and create as many cars as possible.

Food exploration is completely experiential and many of us love to experiment new tastes V

3. Experience based Exploration: To Feel

In this type you explore to experience new things. This can be based on being in another environment to get the zeal and feel of being there. It can also include bungee jumping to explore what all your body can feel.
The feeling which has never been felt before is the end goal of this type of exploration.
A good example of such an exploration is a thrill ride in a roller coater. Or to sky dive to get a different feel that has never been experienced by your body.
The love for variety of foods can also belong to this domain.
the same to make new meanings.

Novelty of things

If you try to see the common thing among all of these three types of exploration is that it closely relates to the factor of NEW or that which is new to the human.

So if I don't know about a particular topic, let's say about Hawks. I can explore to know more about it. This new set of information is what we can consider as the discovery of my exploration.

In case of creative exploration if I want to see the possibilities of what I can do with paper and glue. I have infinite possibilities. All of these possibilities are new to me. Hence when I explore the possibilities I can see a plethora of results which are the discovery of my exploration.

Or say my body has never experienced how it feels like falling down from a plane. When I do it I will realize the new feeling. This new feeling thus becomes the discovery of my exploration.

Overall it's how we as humans know, create or experience.

Each one of these exploratory types is not distinct. And all of these can intersect. Like we can explore to create knowledge instead of considering existing knowledge or we can explore to create experiences. We can also explore to know about creativity or we can explore to know about experiences.
We can also explore to experience creativity or we can feel a new experience by exploring knowledge.

All of them are interconnected and the complexities thereafter.

Why do we explore?

The activity of exploration has been researched a lot among animals and humans. [42]
There are two distinct schools of thoughts that vary in such explorations.
Exploratory behavior can be Extrinsic or Intrinsic. [43]
Extrinsic exploration is seen as a behavior primarily directed towards an external goal in response to some specific requirement. For example it involves an active seeking of a particular outcome such as finding food when hungry or encountering a means of escape from a dangerous environment.

Intrinsic explorations on the other hand are seen as exploratory acts that are not instrumental in achieving any particular goal other than performance of the acts themselves. It is a behavior that that facilitates investigation mainly in response to an interest in the stimuli for their own sake.

Intrinsic exploration has also been referred to 'novelty seeking', reactive curiosity or sensation seeking. In simple words when we do intrinsic exploration we tend to reply "I don't know why I am doing it, but I am doing it"

Higher forms of needs like those specified by Maslow [44] can drive to further levels of exploratory activities. And they may very much connect the extrinsic behavior to that of intrinsic. For example if I have a need for self actualization my exploratory attempts may be very different from those over basic needs like hunger.

Curiosity, which is seen as a precursor to exploration is also seen as one of the major reason for exploration. It is believed that curiosity is a motivational prerequisite for exploratory behavior.[45]

So over all we can see a general pattern or process

" Curiosity -->Exploration --> Discovery "

However curiosity and exploration are very difficult semantic constructs to be defined and the circularity of these terms make them more difficult to be defined in a particular domain.

We may not be able to define the human motives for exploration however the fruits of exploration have been useful to mankind. One such area of study has been exploratory learning. The next section discusses more about it.

Exploratory Learning

"You can't teach people everything they need to know. The best you can do is position them where they can find what they need to know when they need to know it."
- Seymour Papert

Learning theories have tried to model different ways in which learning as an activity can be optimized. Pedagogical models have evolved with different schools of thought trying to describe how people learn and hence trying to state methods to help people do the same.
Constructivism, Cognitivism and Behaviorism are some major learning theories.

Behaviorism focuses only on the objectively observable aspects of learning, and discounts the internal processing that might be associated with the activity. For behaviorism, learning is the acquisition of new behavior through conditioning.

Cognitive theories look beyond behavior to explain brain-based learning.
Cognitivists consider how human memory works to promote learning.

Constructivism on the other hand views learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge. In other words, "learning involves constructing one's own knowledge from one's own experiences."
Apart from these three major learning theories there have been a recent theory called connectivism which claims to be a combination of the existing learning theories for the digital age.
Discovery learning or exploratory learning is a variation to Constructivist theory of learning. It is considered as an inquiry based learning approach and is the work of theorists like Jean Piaget, Jerome Bruner and Seymour Papert.[46]

Exploratory learning believes that it is best for learners to discover facts and relationships for themselves.

It is an inquiry-based, constructivist learning theory that takes place in problem solving situations where the learner draws on his or her own past experience and existing knowledge to discover facts and relationships and new truths to be learned. Students interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. As a result, students may be more likely to

"...it is best for learners to discover facts and relationships for themselves."

remember concepts and knowledge discovered on their own. Models that are based upon discovery learning model include: guided discovery, problem-based learning, simulation-based learning, case-based learning, incidental learning, among others. [47][46]

Exploratory learning in Software

The theory of exploratory learning has also been applied to software considering the extra effort needed to learn software's [48]. A very good example is the folder structure exploration. Once we know clicking opens a file exploration becomes natural.
The potential value of exploratory learning has been recognized since interactive computing first began to enter the workplace. The success of computer games has been noted and it has been argued that other computer software should have some of the same characteristics. Mastering the software should be intrinsically motivating; features should be revealed incrementally; and the system should be at least minimally useful with no formal training.

^Different learning theories explain different ways of human learning system.

Exploratory Learning Framework.

Exploratory learning can be looked at from different existing models that explain the activity of exploratory learning.
Thinkering Spaces [49] is a project at IIT institute of design which focuses on exploratory learning. They have compiled a framework from different learning theorists and current experiments. The following are the four frameworks which help in further understanding the model of exploratory learning:

1. Modes of Interaction

Engagement	Exploration	Elaboration	Extension
enter orient select	sense focus accept	initiate iterate evolve	connect explain transport

According to this concept in case of exploratory learning the kids can be provided four modes of interaction:

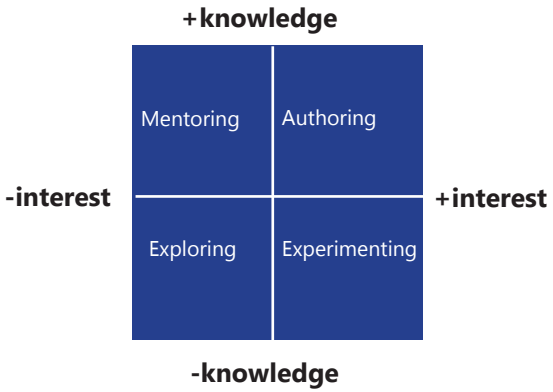
a. Engagement
This shows how the kids can get oriented towards the object or zone of exploration. It acts as an initial impetus to curiosity

b. Exploration
The act of initiating open-ended play activity using available materials and objects.

c. Elaboration
The interaction to build on their ideas and goals derived from the exploratory activity to maintain interest and focused attention.

d. Extension
This involves extension of the queries, comments and communications when not in contact with the exploratory zone or object.

2. Knowledge interest engagement
It states how the activity of the kids can differ based on the starting point for engaging in self directed discovery. These activities depend on the prior knowledge of the kids. Engagement tactics can respond to the knowledge and interests of kids:



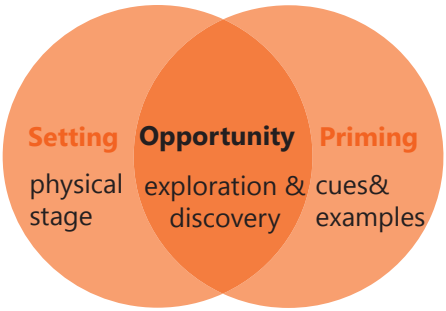
Low knowledge / low interest
Encourage exploration.

Low knowledge / high interest
Provide ways to question through experimentation.

High knowledge / low interest
Use social interaction to engage through mentoring.

High knowledge / high interest
Allow contributions of additional information through authoring.

3. Setting/Priming/Opportunity
Since exploratory learning allows explorations without any external assignments and protocols, settings and priming's are key creation of successful interactions.



Settings as in physical stage are the physical spaces that need to be considered where the interaction will occur. These settings should be such that the content of the exploration should be signified.

Priming is key aspect to exploratory learning and can help in creating curiosity or experimental behavior. Display of a related task can prime in experimentation easily.

Opportunity is the exploratory potential resulting from setting and priming. Opportunity activities fall into various exploration modes such as: mimic (looking at examples and copying), combine (putting objects, images or ideas together in unique ways), transform (finding ways to change what is in hand through operations such as scale, symmetry, transposition, etc.) and invent (serendipitously creating a completely new object, image or idea).

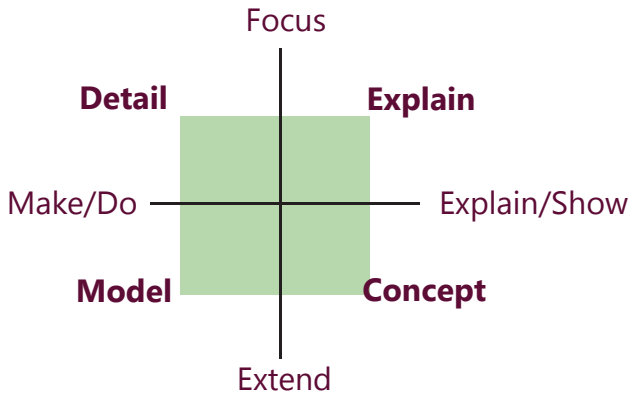
4. Make/Do>> Explain/Show
This model describes the relationship between actions (Make or Do explorations) and expressions of achievements or new ideas (Show or Explain the results to others).

Make/Do is about hands-on experience where the self-defined activities of children help them to acquire understanding, construct meaning and evolve their own

learning goals. And, upon reflection, adjust their goals and actions in order to expand both their experience and understanding.

Explain/Show is about heads-on experience where kids share their learning experiences with others in the social/collaborative environment. Here, as in the Atelier, children learn the value of social settings and thereby social construction. The resulting intention is to improve kid's knowledge of both the physical and virtual worlds.

Focus is about the inward, micro-view and Extend is about the outward, macro-view. Here, in the Make/Do >> Show/Explain model, achievements and new knowledge are reflected by showing examples or explaining broader more general concepts.



4.3 Gesture based interaction

<Reactrix-WaveScape showing gesture based interactivity with Samsung vertical screens at CES 2008

From GUIs to multi-touch, speech to gesturing, the ways we interact with computers are diversifying as never before. Gestures are now becoming the next generation interaction technology.

As we saw in previous chapters the impact of gestures across domains is unparalleled. When coupled with technology for interacting, the importance of gestures is clearly seen.

In interaction terms gesture based interaction is a process of using body gestures to control or command the machine.
In the context of this project gestural interaction is synonymous to hand gestures. In specific case of this project it is the process of using hand gestures to control or command the computer to explore.

Gesture based interactions are not new to HCI domain. They have existed in the background for 40 years. The input techniques have however varied and progressed with time.

Even beyond HCI starting from mere gesture based response can be seen as the early start of gesture based interactions. Some examples of the same are clap switches, which got triggered on the gesture of clapping.
Automated taps and flushes are also good examples of gestures where the proximity of our hand or body to the sensor produces the output.
These can be considered as basic gesture based interactions. However the first HCI based implementation on record can be considered as the work done by Ivan Sutherland called sketchpad.[50]

How it evolved

Just a brief history of the evolution of hand and body gesture based interactions.

^**Theramin used like in an orchestra**

1920: Theramin
Gesture based interaction is even older than 40 years if we see the record of a specific musical instrument called Theramin. Built in 1920 Theramin is one of the oldest electronic musical instruments. This responds to hand position using two proximity sensors, one vertical, and the other horizontal. Proximity to the vertical sensor controls the music pitch, to the horizontal one, loudness. What is amazing is that music can be made with orthogonal control of the two prime dimensions, using a control system that provides no fixed reference points, such as frets or mechanical feedback. The hands work in extremely subtle ways to articulate steps in what is actually a continuous control space [51] However since it is not a computing device it doesn't qualify in the race.

^**Ivan Sutherland using SketchPad**

1963: Sketchpad.
Considered to be the ancestor of modern Computer Aided Drawing sketchpad was a computer program written by
Ivan Sutherland in his PhD thesis in 1963.
Sketchpad was the first program ever to utilize a complete graphical user interface, using an x-y point plotter display. And to the surprise it was one of the inspirations of Dougless Engelbart to invent the mouse.

1970: VideoPlace
Developed in the late 1970's and early 80's by Myron Krueger, videoplace uses real time image processing of live video of the user. Background subtraction and edge detection are used to create a silhouette of the user and relevant features identified. The feature recognition is sufficiently fine to distinguish between hands and fingers, whether fingers are extended or closed, and even which

^**Videoplace uses realtime gestures**

fingers. With this capability, the system has been programmed to perform a number of interactions, many of which closely echo our use of gesture in the everyday world.

1987: DataGlove

The first commercially available hand tracker was the Dataglove. This used thin fiber optic

^ **CyberGlove had direct mapping to the virtual**

cables running down the back of each hand, each with a small crack in it. Light is shone down the cable so when the fingers are bent light leaks out through the cracks. Measuring light loss gives an accurate reading of hand pose. The Dataglove could measure each joint bend to an accuracy of 5 to 10 degrees. Its predecessor was the CyberGlove which has evolved in glove based input devices.

Natural free form gestures as displayed in the above show use of more of manipulative gestures.
However symbolic gestures are also few which have been evolving in vision based gesture computing.

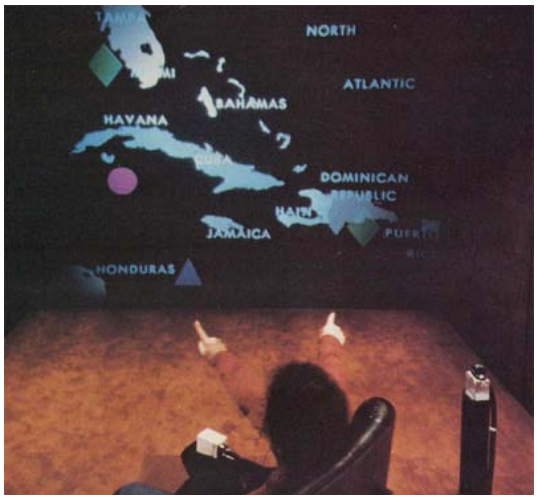
1992: Rubber Rocks

In Rubber Rocks virtual environment, users could pick up virtual rocks by making a fist gesture and throw and release rocks with a flat hand gesture.

1993: GIVEN

The GIVEN virtual environment (Gesture-driven Interactions in Virtual Environments), uses a neural network to recognize up to twenty static and dynamic gestures (Vaanan-en and Bohm, 1993). These include pointing gestures for flying, fist gestures for grabbing and other whole hand gesture for releas-ing objects or returning back to the starting point in the virtual environment.

Multi Modal Interactions are also interesting evolution in the field of gestural interactions.



^ **"Put that there " shows the use of pointing**

1980: Put that there:
It was one of the first works in multimodal interactions done by Richard Bolt [52]. In this work deictic gestures are used to create and move objects.

1984: Media Room:
Followed by the work of "Put That There" was the Media Room constructed by Negroponte's Architecture Machine Group. Designed by Richard Bolt, the Media Room allowed the user to sit inside the computer interface and interact with the computer through voice, gesture and gaze. It consisted of a large room, one wall of which was a back projection panel. The user sat in the center of the room in a chair wearing a magnetic position sensing devices on their wrist to measure pointing gestures

Within the Media Room the user could use speech, gesture, eye movements or a combination of all three to add, delete and move graphical objects shown on the wall projection panel. The computer interpreted the user's intentions by speech and gesture recognition and by taking the current graphical situation into account.

2001: LionHead game Black and White.
Lion Head was one of the first games that allowed control of onscreen objects using 3D glove. This was a virtual reality glove that allowed manipulation of virtual hands using real hand motions.

Many more gesture based experiments have been undertaken which explore different possibilities of gesture based interactions in different contexts.

Emerging Gesture based products

There have been many emerging gesture based applications.
Each one of them has kept the users at the edge of their seats.
Most of these applications are a merger of software and hardware.

1. Eye Toy with PS2 [53]:
Sony launched a supplement to Play Station2 called EyeToy in 2004.

^A first person game using Playstation Eyetoy

Eyetoy is a technology that allows users of PS2 to enjoy games by being a part of the game themselves (a concept like augmented virtuality). It is a color digital camera device, similar to a webcam.
The camera uses computer vision to process images taken by the camera. This allows players to interact with games using motion, color detection and also sound through its in-built microphone.
PS2 has special eyetoy friendly games which are continued with PS3.
Features like Cameo allow you to scan your face and replace the virtual players (avatars) face by that of yours.

2. Nintendo Wii [54]**:**
Nintendo had been second in race when it came to competition with Sony's PlayStation or Microsoft's Xbox. Although Nintendo was among the first companies to start with arcade games and gaming consoles
Nintendo Wii is the fifth console launched by the company and it surely made waves.

Launched in 2006, Wii changed the way games can be interacted with.
Wii allows users to get an immersive interaction experience.
It has a remote called as the "Wiimote" which senses motion on the basis of accelerometers and laser sensing technologies.

<Nintendo Wii WiiMote and console

Amit Patil
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Wii has become an instant hit in the market, and off late Nintendo launched the WiiFit which focuses on fitness and fun together.
WiiFit comes along with a Wii Balance Board peripheral that allows users to stand on it and interact with on screen games.

3. Logitech Air [55]:
Produced by the leaders in mouse technology LogitechMX AIR has made the mouse mobile. It is a free space wireless mouse that allows control of screen pointer in free space, 3D motion. The sensor transforms hand motions into natural, responsive cursor controls. Adjust volume by waving to the right or left; skip tracks with a flip of the wrist.

Logitech MX AIR mouse allows 3D gesture based navigationV

4. GestureTek Gesture Point [56]:
Gesture Point is a technology that allows interacting with the virtual touchless.
It uses computer vision technology to do so. It is also said that Microsoft is collaborating with GestureTek to add gestures to their Xbox Gaming console soon.

5. 3DV systems: Zcam [57]**:**
It is a camera that recognizes depth in real-time. According to the company, the 1.3-megapixel ZCam captures video at up to 60 frames per second, isn't a drain on CPU resources and will be priced at less than $100.

^ ZCam is a camera that recognizes third dimension

6. TouchLight [58]
EON Reality is a company that creates immersive experiences with combination of its advanced software's and display systems. Touch light is one of their major products that let you to interact, by simply pointing with bare hands, with smart 3D content that appears to float in space on the transparent screen pushing the boundaries of digital experience closer to reality.

7. Microsoft Surface [59]:
This gesture based table allows use of multi-touch gestures on a flat surface.
Aptly named Microsoft surface it displays scenarios which change the way we interact with digital content.

8. Apple iPhone [60]:
When launched in June 2007 iPhone was an instant hit among people due to its multi-touch technology. Apart from its multi touch based technology iPhone also supports

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motion based, proximity based gestures. It uses the concept of onscreen controls which can be interacted with using touch gestures.

9. Sony Phones [61]
Sony has launched few models that detect gesture based interactions like the Z555 allows muting of the phone or alarm by just moving your hand back and forth over the phone.
While the Sony walkman series of phones are integrated with motion sensing and allows gestures like shaking the phone to change the track etc.

^ Sony Erricson Z555 can turn off alarm by wave

10. JVC TV [62]**:**
JVC is in the phase of manufacturing a Television Set with Gesture Control without using the Remote Control, which is shortly to be released in the market. Using a microphone and a video camera, the TV can pick up claps to change volume, and recognize a pointing finger to control elements on the screen (apparently you bend your finger to "click".)

11. Samsung TV [63]:
Reactrix and Samsung introduced gesture controlled TV operation in the CES 2008. More noticeable, the stall at CES, in Las Vegas has interested several visitors with the Live demo. One of the most popular has been the WAVEscape advertising platform, developed by Reactrix and exhibited in partnership with
Samsung.
WAVEscape is a stereo near-infrared vision system that sits above a television to enable interactions between viewer movement and content on the screen.

^ Samsung and JVC have introduced television sets that allow free hand gesture based interactions