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Collage of Administrative Science and Informatics
Department of Information Technology

Real Time Object Tracking in 3D Virtual Environment

Research team

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This research is submitted in partial fulfillment for the degree of B.Sc in Information Technology.

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Dedication

To our precious parents how have lightened our way........

To our best friends, brothers and sisters, thanks for your support......

To Hamdi H Al- Mohtaseb, Safa Abu-Shameh

Research team

Thanks and Appreciation

At the beginning of this research, we can only express our sincere thanks and appreciation to all who contributed to this work, to each of fatigue in this matter will come to work in complete image most notably dear martyrs Mousa Irfa'ya Supervisor of this research, and who sent us advice and guidance.

Research team

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Declaration

The research team announces that the information contained in this research are correctly, documented and that we are legally accountable if it is proved otherwise.

Research team

List of Abbreviations

2D	Two Dimension
3D	Three Dimensions
VR	Virtual Reality
VE	Virtual Environment
VRML	Virtual Reality Modeling Language
SDK	Software Development kit
APIs	Application Programming Interfaces

Abstract

In this research we have developed a new technique for studying consumer navigation patterns depending on real time object tracking in 3D virtual environments, we were able to capture consumer's navigation coordinates and present them in charts, the charts can be used by consumer behavior analysts to help them analyze and understand a consumer behavior in depth .

Research organization:

- Chapter one: includes the research objectives, scope limitation and challenges.
- Chapter two :includes a general background
- Chapter three: includes the literature review.
- Chapter four : includes the requirement specifications
- Chapter five: includes the research design (context diagram, data flow diagrams and the flow charts).
- Chapter six: includes the project description.
- Chapter seven: includes the research implementation methods and functions and classes.
- Chapter eight: includes the results, conclusion and future work.

Chapter One
Introduction

1.1 Overview:

Over the years consumer behavior studies relied on observing consumer's navigation and interaction patterns in physical real world, the process included a large number of activities from physically tracking users while shopping to using numerous cameras to capture consumer's behavior in shopping locations, and even trying to capture the consumer's eye movements!. These activities are very expensive, time consuming, and the information provided is neither sufficient nor reliable.

Today's consumer behavior studies are moving to wards technology based on 3D virtual reality environment. This system simulates the desired study environment and enables researchers to study consumer's behavior at real time and provides a high level of control over the simulated environment, information reliability and accuracy.

"Human history is marked by a progression of media used to convey and experience ideas"[1]

R.Sherman .William, , 2003," understanding virtual reality interface application and design", Elsevier Science, USA: p. 5 [1]

1.2 Research objectives:

In this research and by implementing a new virtual reality based technology we aim to:

1. Explore new technologies and techniques and benefit from the latest works presented in our field of major.
2. Focus on the unique features and advantages of using 3D virtual environments in capturing, analyzing and understanding the data required to provide detailed information about consumers and their behavior patterns.
3. Provide better understanding for physical space depending on 3D simulation in attempt to reduce the time and effort spent on tracking consumer behaviors in real world.

1.3 Research limitations and scope:

1. The research will be delivered to the supervisor within 16 weeks
2. The research budget is limited.
3. the research study includes an experiment that fulfils the following terms:
   - The study is based on a 3D virtual model.
   - The 3D model is interactive.
   - A lighting technique is used to provide realism to the 3D environment.
   - A camera is used to help users visualize the 3D environment.
   - Users will move in the 3D environment using the traditional keyboard.
   - User's movements are captured and saved for analytical purposes.

1.4 Research methodology:

The research is based on the scientific research methodology.

1.5 research description:

This research is based on the deployment of 3D virtual environments in studying and analyzing consumer behavior patterns, by using a 3D shopping center model which is built using mixed reality components in order to provide a sense of realism, And by implementing some navigation properties, users will be allowed to navigate through the model, at the same time the system will track users and save their navigation data into a special file for each user. The data will be used by analysts to provide better understanding for consumer behaviors and that is the main purpose of this research.

1.6 Research challenges:

The project team encountered technical problems that needed to be solved, the most cited ones were:

1. selecting the appropriate programming language:

Because our work connects different technologies: 3d modeling and object tracking, it was not easy to find a programming language that integrates these technologies .after counseling specialized programmers and searching over the web we decided to use Microsoft Visual C# Express Edition with Microsoft DirectX 9.0 SDK library . Some of the useful links we found are:

http://www.c#corner.con

http://www.csharpfriends.com

2. lack of experience in the selected programming languages:

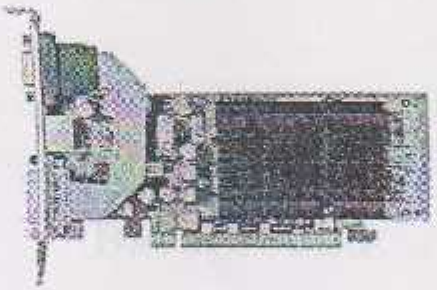
Basically DirectX is used for game programming and it is not widely used in our field of major, we couldn't find any one to consult .after long search we were able to find a few forums that focuses on programming with DirectX.

Most useful forum was:

http://forums.microsoft.com/MSDN/default.aspx?ForumGroupID=20&SiteID=1

3. using the correct screen card:

We found out that using DirectX to load and present 3d models requires a special graphics card which is very expensive it costs about 149$.



Picture 1.1: graphics card

Modern devices now have built in graphics cards; and we managed to find a device that supports our specifications.

4. finding a technique for optimizing and loading materials to the project work space:

This problem is connected to the previous one except in this case the solution was in the programming code; we used some additional methods to support material loading and viewing. A useful link:
http:// www.XNAtutorials.com/directx

Chapter Two
Background

2.1 Overview:

Virtual reality was defined for the first time in 1989 by Webster dictionary as "being in essence but not in fact"[2], by time and due to the huge development of hardware technologies it became a magnificent science that is irreplaceable to man kind, nowadays it is cited as a form of human-computer interaction in which a real or imaginary environment is simulated and users interact with and manipulate that world and enables the use of advanced technologies, including computers and various multimedia peripherals, to produce a simulated environment that users perceive as comparable to real world objects and events.

One of VR major elements is the virtual environment which is considered as an interactive, virtual image displays enhanced by special processing and by non visual display modalities, such as auditory, to convince users that they are immersed in a synthetic space. This type of system has three major elements: interaction, 3-D graphics, and immersion.

There are many programming tools that assist in creating and customizing virtual environment such as DirectX it suggests a very new technology for managing and manipulating graphics, in fact it is defined as a collection of functions that govern sound, video, network communications as well as the graphics.

R.Sherman .William, , 2003," understanding virtual reality interface application and design", Elsevier Science, USA: p.6[2]

2.2 Virtual Reality applications:

There are many applications for virtual reality, these application include:

1. Visualization and representation:

It enables users to interact with the simulation to conceptualize relations that are not apparent from a less dynamic representation, and to visualize models that are difficult to understand in other ways.

For example, a virtual environment has been developed that allows clothes to be displayed to retailers at their convenience. In an effort to respond more quickly and accurately to market demand, designers create virtual fashion collections which are then modeled to buyers by 3-D models. This technique introduced an element of designer-retailer collaboration which, in theory, can enhance the quality and suitability of clothes as well as the speed with which they are available for sale.

2. Hands on training:

The most common work-related applications of virtual reality are those that utilize its immersive and interactive nature to approximate actual hands-on training. VR is currently used to train operators of various kinds of equipment, where initial training in a virtual environment can avoid the expense, danger, and problems of monitoring and control associated with training in the real life situation.

3. Orientation and navigation:

Virtual reality is well suited to help users learn to navigate in unfamiliar or complex surroundings. A number of studies have shown that navigation in virtual reality models of complex buildings generalizes to actual buildings. Other studies have found that military personnel using self-guided virtual terrain environments can learn successfully the actual physical terrain that had been simulated.

2.3 Advantages of Virtual Reality Systems:

There are many reasons why VR systems are being used more often these days, among the most frequently cited are the following:

- Flexibility.
- Inherently safe.
- Wide application.
- Intuitive interaction.
- Motivating.
- They will exploit interactivity.

Finally, "The development of new virtual reality technologies will lead to important changes in daily social and economic life, and will raise a number of important topics in the field of ethics, in moral philosophy, in political philosophy, and in existential philosophy."[3]

2.4 Virtual Environment:

Virtual environments is an interactive, virtual image displays enhanced by special processing and by non visual display modalities, such as auditory, to convince users that they are immersed in a synthetic space. This type of system has three major elements: interaction, 3-D graphics, and immersion.

[3] Virtual Reality Applications to Work (Published in WORK, 11 (3): 277-293, 1998) Patrice (Tamar) Weiss and Adam S. Jessel

2.5 Elements that affect the realism of a virtual environment:

- Fidelity -- high-resolution graphics
- Display of organ properties.
- Display of organ reactions.
- Interactivity -- between objects
- Sensory feedback.

2.6 DirectX Usage:

DirectX provides a key set of tools and commands to enhance 3D interactive products and other multimedia applications allowing the hardware and the software to "talk" to each other with greater ease. The APIs (Application Programming Interfaces) gives multimedia applications greater access to the advanced features of high-performance hardware such as three-dimensional (3D) graphics acceleration chips and sound cards. They also control many other lower-level functions; this includes two-dimensional (2D) graphics acceleration.

2.7 Object Tracking:

Object Motion tracking refers to the acquisition of the coordinates of moving objects relative to a stationary reference. 3D Motion Tracking defines the camera position within the 3D space of the shot, which allows the artist to integrate computer generated elements into the shot.

Object tracking is an independent process that manages creating, monitoring, and removing tracked objects; each tracked object is identified by a unique number .The tracking process periodically polls the tracked objects and notes any change of value. The changes in the tracked object are communicated to interested client processes, either immediately or after a specified delay.

Chapter Three
Literature Review

3.1 Overview:

Using 3D modeling and object tracking has became a very interesting and challenging approach for many people, in fact this technology was tested in many fields such as geography, manufactory, marketing, social sciences, etc....

Many recent projects were based on using 3D VE modeling to explore and understand the physical reality better; these projects results were very promising and encouraging and made the case of VE modeling even more interesting. And there are many previous, interesting related works regarding the use of 3D VEs in deferent fields.

3.2 Related work:

An Information Database for VRML Cities **[Heinonen, Pulkkinen - 2002]:** a system was presented to visualize information about city with a three-dimensional web user interface; a novel way was used to connect a VRML world to an information database. The data, code and models were kept separate, updates and maintenance of the system were easy. An experimental immersive interface was also made.

The location of any service, shop etc. was shown both in a 3D world and on a 2D map, which were interconnected. This implementation works on standard web browsers. In addition, the developers built an optional steering wheel navigation, which was considered as an intuitive way of moving around in the city for home Internet users. And so the information visualization of a city became easier and more intuitive in 3D.

A Visual Tool for Tracing Users' Behavior in Virtual Environments **[Chittaro, Leronutti]:** a tool, called VU-Flow, was proposed it is able to automatically record usage data of VEs and then visualizes it in formats that make it easy for the VE designer to visually detect users' behaviors and thus better understand the effects of their design choices. In particular this case visualizations concerns were:

- The detailed paths followed by single users or groups of users in the VE.
- Areas of maximum (or minimum) users' flow.
- The parts of the environment more seen (or less seen) by users.
- Detailed replay of users visits.

Some examples were presented to explain how these visualizations allow one to visually detect useful information such as the interests of users, navigation problems and users' visiting style. Although this case described how VU-Flow can be used in the context of VEs, it also indicates that the tool could be also applied to the study of users of location-aware mobile devices in physical environments.

VU-Flow: A Visualization Tool for Analyzing Navigation in Virtual Environments **[Chittaro, Rannon, Leronutti -2006]**: presented a tool for the visual analysis of navigation patterns of moving entities in a 3D Virtual Environments (VEs). The tool, called VU-Flow, provided a set of interactive visualizations that highlight interesting navigation behaviors of single or groups of moving entities that where in the VE together or separately.

On Design of 3D and Multimedia Extension of Information System Using VRML **[Zara,Cernocorsky -2000]:** this search presented an experimental approach to information system based on virtual reality. The goal of the presented experimental system was to extend already existing information system by spatial and multimedia information with respect to needs and requirements of students, teachers, and visitors. The important condition was the possibility to change a model according to changes of the real state.

The basic part of the system consists of 3D model of the Department of Computer Science & Engineering at the" Czech Technical University". The model has been created in VRML and stored in a standalone database. The information system provides three main functions: retrieving information from the model, automatic navigation, and interactive editing of 3D model. The last function allows changing the appearance of classrooms and offices as well as manipulating furniture and other objects within those rooms. The system is fully controlled via Internet.

Virtual reality in the mining industry **[Schofield, Denby, McCalarnon-1995]:** In this research a German mining company (DSK) which is also actively engaged in introducing the latest 3D technologies into the company's working processes, most notably in the dynamic visualization of mine configuration. It produced an interactive 3D representation of AVSA which would allow the user to try out most of its functions in a virtual environment. An animated VRML model was created. The functionalities of the interactive model could be started by using corresponding control buttons within a 3D environment. The user could also navigate in all directions and choose various camera positions including viewpoints not available in the real environment.

3D Representations for Software Visualization **[Marcus,and feng]:** the main focus of this research was the visualization of large scale software to assist in understanding and analysis tasks associated with maintenance and reengineering. Developers present a new 3D representation for visualizing large software systems. The representation was based on the SeeSoft metaphor and extends the visualization mechanisms by utilizing the third dimension, texture, abstraction mechanism, and by supporting new manipulation techniques and user interfaces. By utilizing a 3D representation they were able to better represent higher dimensional data than previous 2D views.

This was a very important case because software visualization system is often extremely difficult

The Challenges of 3D Interaction **[Herendon, Vandam, Gleicher- 1994]:** the case main aim was understanding more about these difficulties, and their many diverse sources - users' perceptual, cognitive, and skills and abilities, limitations and nature of 3D tasks, and the variety of implementation strategies and development environments.

The case led to facts emphasis that:

- 3D graphics applications are significantly more difficult to design implement and use than their 2D counterparts.
- Learning to implement or use 3D graphics software is still extremely difficult; and the most effective ways for humans to interact with unreal 3D environments are still not clear.

Real-Time Techniques for 3D Flow Visualization **[Fuhrmann ,and Grijler]:** This case aims to overcome the Visualization of three-dimensional problems including: lack of directional and depth hints to become effective. Several techniques that facilitate 3D flow visualization within a virtual environment were proposed. The developers introduced anew adaptive texture mapping method shows that texture hardware can be efficiently used. Developers found that 3D phase space contains spatially complex structures, which are difficult to interpret, and the added cues of a virtual environment (e.g., stereoscopic viewing, interactive and intuitive viewpoint change) are quite helpful when inspecting these structures.

Visualization Strategies and Tools for Enhancing Customer Relationship Management **[Ganapathy, Ranganathan-2004]:**In this case a visualization tool was developed to assist in studying consumer behavior in E-commerce market places the study objective was to eliminate Web sites with poorly designed search functions, clumsy online catalogs and limited tools to assist customers in their purchase process. Common tactics were used to attract consumers including displaying product images, and showing products via 3D views. Quick-Time Virtual Reality (QTVR) was introduced as an alternative for online merchants to present 3D views of the products, 3D options were more expensive than traditional image views, and customer satisfaction that results in more purchases could easily offset the high costs.

3.3 Conclusion:

Despite the fact that each one of these cases is focusing on a different filed of specialization there are some common and very important results among them, and the most cited research results are the following:

- The 3D graphics are proven to be a better way to represent reality than with symbolic 2D maps. With the coming advances in hardware, 3D environments will eventually be a very common way to show location-based information.
- These 3D visualizations will provide very detailed information about user's behavior in virtual environment space.
- 3D visualization allows for an improved decision making process. The simulation of equipment functionality in a virtual environment also helps to estimate at an early stage any potential logistical problems. 3D technology is effectively used in the introduction of new equipment in both business presentations and personnel training.
- It was effectively used in discovering navigation patterns, highlighting critical situations, and prompting usability improvements.
- This technological edge is proven to be a boon for retailers in the race for market supremacy and consumer behavior studies.
- This work brings together research from software analysis; information visualization, human-computer interaction, and cognitive psychology.

Chapter Four
Requirements

4.1 Introduction:

In this chapter we will clarify the system development requirements. Basically, the requirements include three main types: hardware requirements, soft ware requirements, and human requirements.

4.2 System Development Requirements:

4.2.1 Hardware requirements:

Hardware requirements represent the specifications of hardware components that should be available in to accomplish the research objectives it includes:

Item	*Quantity*	specification
Personal computer -PC	1	Pentium-4 2800MHz Intel(R) 92965G Graphic controller 256MB DDRAM 400MHz 80GB HARD DISK 7200 RAM 56K PCI Modem 17" SVGA COLOR Monitor PS2 Keyboard,PS2 Scroll Mouse
Express graphics card	1	Supports 3D standards DirectX 9 256MB on-board DDR2 SDRAM Ports: DVI-I, VGA , S-Video TV video Maximum 1920x1200 DVI digital resolution Integrated HDTV encoder: up to 1080i resolution Optional DVI-to-VGA adapter Requires PCI Express x16 slot P/N GC-NV73L2
Removable storage	Multiple	256 MB Minimum
Digital camera	1	Panasonic VX70

Table 4.1: Hardware requirements system

4.2.2 Software Requirements:

The developer prerequisite software's include the following:

- **Visual C# Express 2005 Edition:**

Visual C# Express Edition is a subset of Microsoft Visual C# 2005 comprises the latest C# compiler, and all the tools needed to write, compile, and test applications, utilities, and games. Its most cited features are:

- Integrated developer environment (IDE)
- Powerful debugger for finding and fixing errors.
- Full support for Windows Forms and controls, making it easy to create rich user application interfaces.

- **DirectX 9.0 SDK:**

Microsoft DirectX software development kit (SDK) can be used in Microsoft Windows 98, Windows Millennium Edition (Windows Me), Windows 2000, and Windows XP environments. It is made up of multiple components such as: graphics component, DirectInput component, DirectSound component, DirectDraw.

- **Photoshop CS program**:

The de facto standard in image editing it contains a large variety of image editing features.

- **Anim8or OpenGL program:**

Anim8or is a 3D computer animation program that is designed to allow straight forward creation of animations. It interactively creates and edits objects, figures, and scenes directly on the computers screen.

- **Turbo Demo**:

It is a powerful and easy-to-use program allows you to create fantastic and interactive demos, tutorials, simulations, and movies without any programming knowledge.

- **Converter (conv3ds):**

Conv3ds converts 3ds models produced by Autodesk 3D Studio and other modeling packages into X Files. By default it produces binary X files with no template.

- Windows XP professional.
- 3ds Max multimedia program
- Microsoft Visio program.
- Microsoft Office 2003.
- VRML
- Adobe premiere

Chapter Five
Design

5.1 Introduction:

In this chapter we will focus on our system design and its relationship with the surrounding environment, the system data flow diagrams will be specified here.

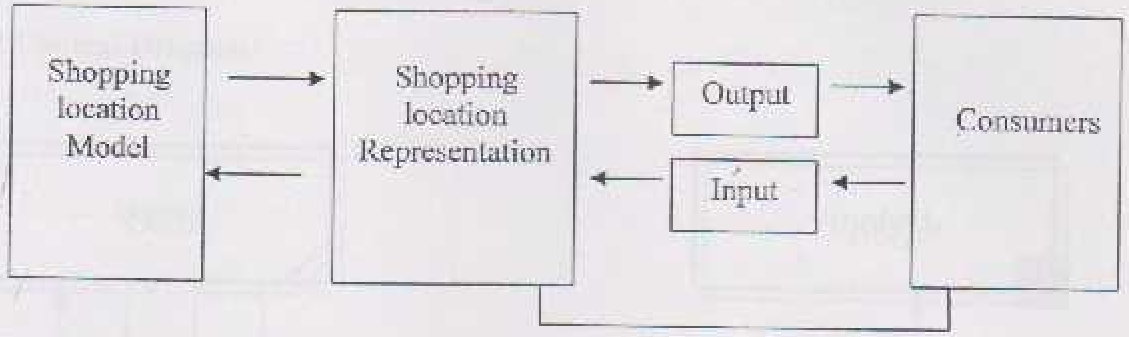


Figure 5.1: virtual shopping location general system model

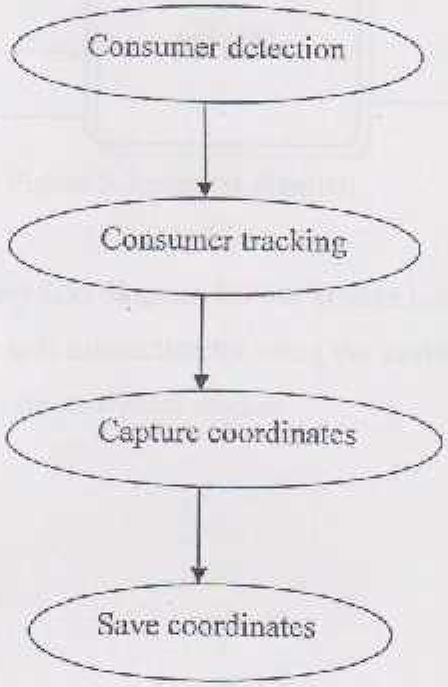


Figure 5.2: out system tracking process model

Figure 5.2 shows the steps of consumer tracking process, first the system recognize the consumer entrance to the system then it initiates the tracking process which is followed by capturing consumer position coordinates and then saving them into files for advanced usage.

5.2 Context Diagram:

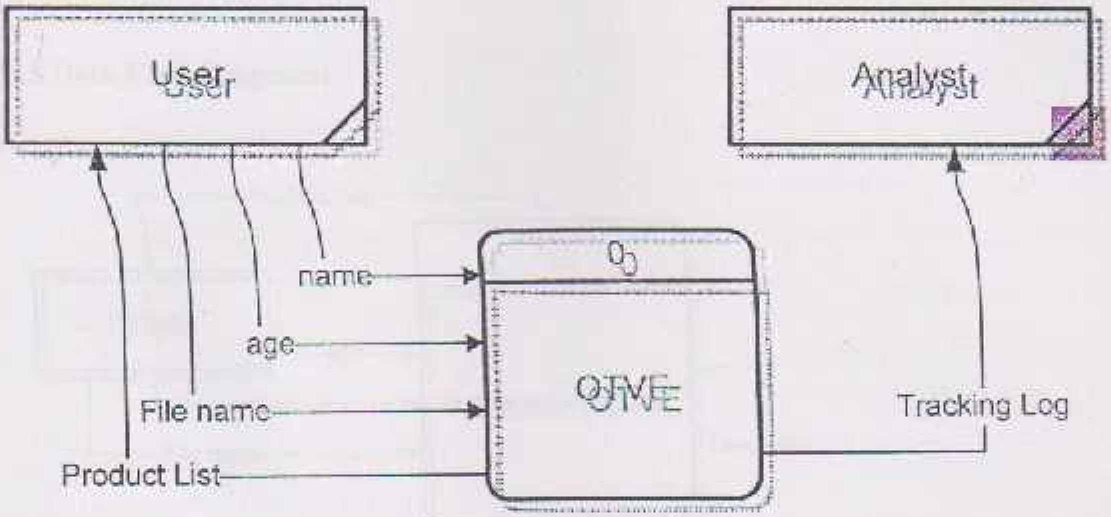


Figure 5.3 context diagram

Figure 5.3: demonstrates the context diagram for our system including its main functions. The system allows user interaction by using the keyboard, the system also records user activity locations for analytical studies

The system is divided into a group of subroutines each with a specific action to perform figure 5.2 illustrates two main subroutines, the first represents the process of gathering consumer data in order to initiate their personal files .the second one is the process of tracking consumer navigation, in this process the system captures the consumer navigation coordinates in the form of location (X, Y, Z) , afterwards the each consumer navigation coordinates are saved into his personal profile file to be used later by analysts .

5.3 Data Flow Diagram:

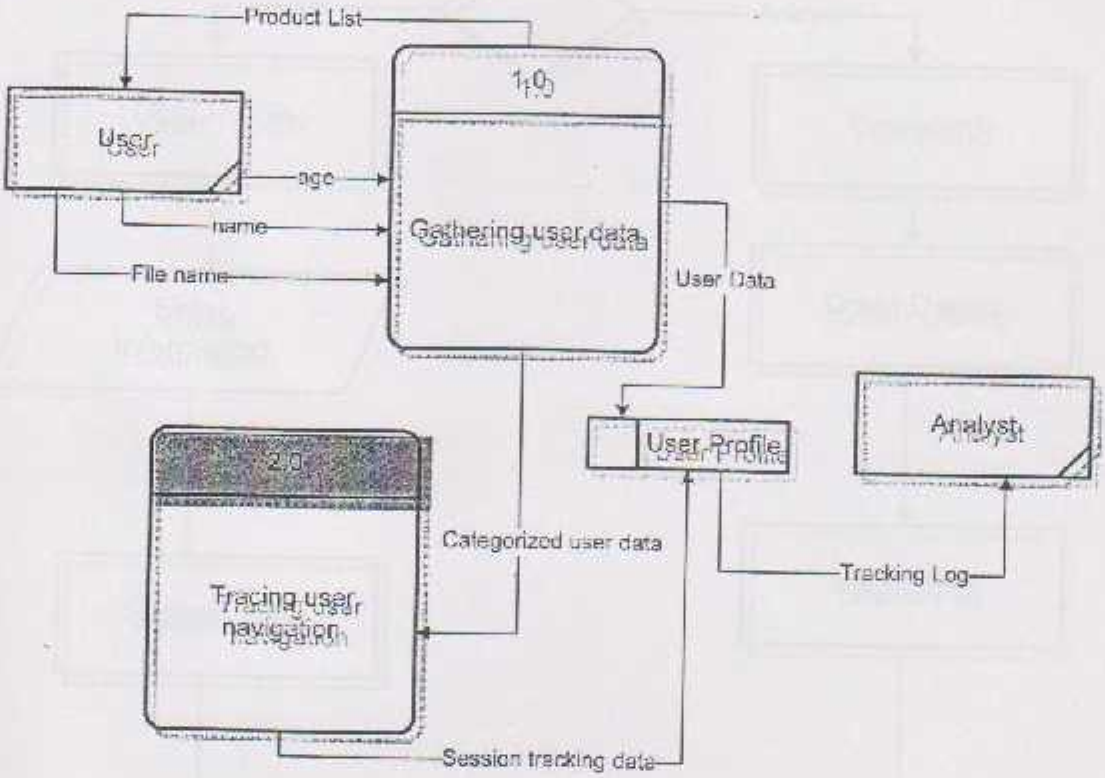


Figure 5.4 DFD level one

5.4 System Flow charts:

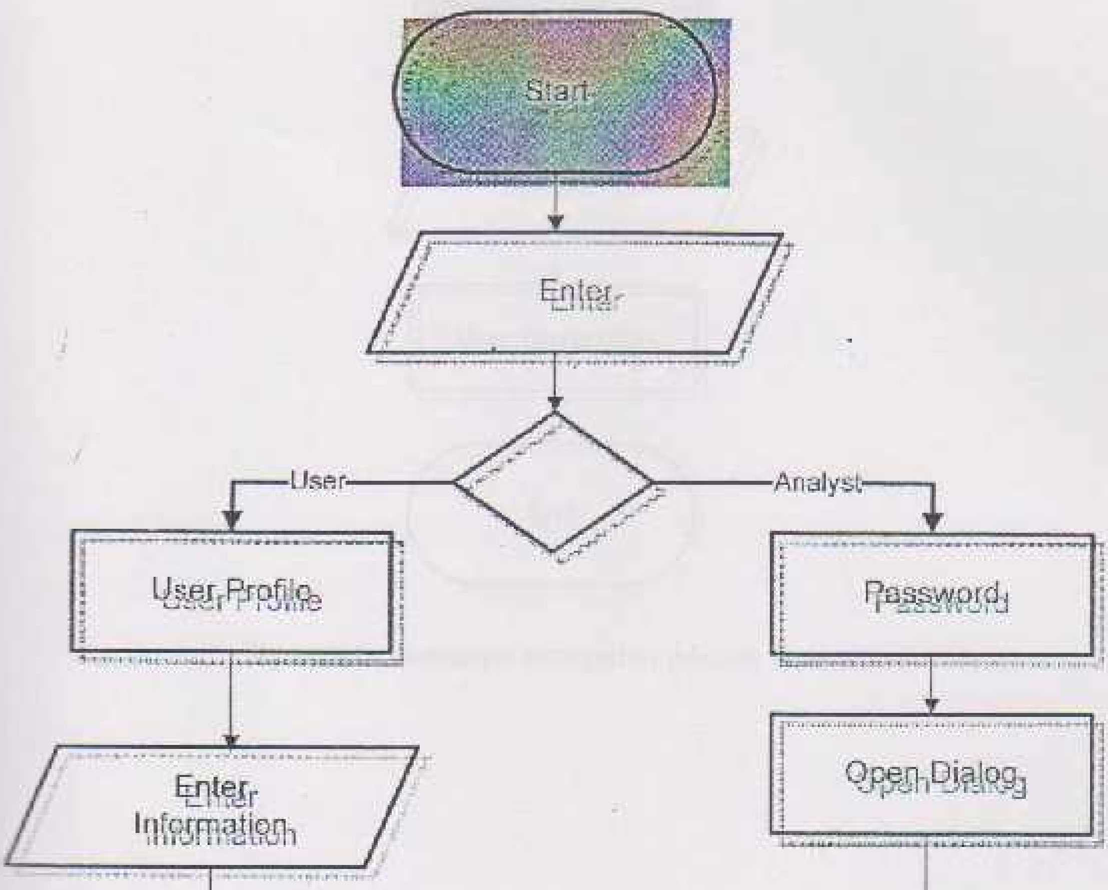


Figure 5.5: the consumer and analyzer system access process flow chart

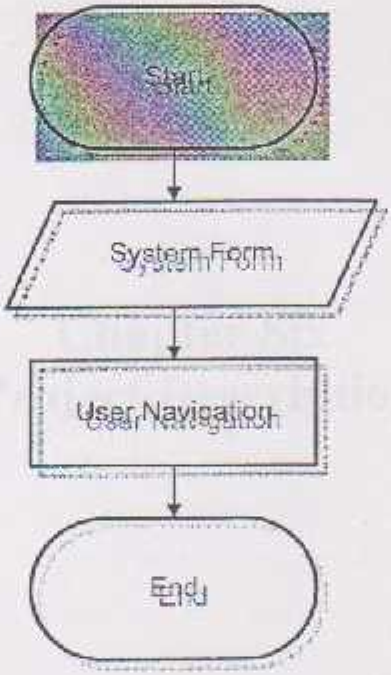


Figure 5.6: consumer navigation process flow chart

Chapter Six
Project Description

6.1 Introduction:

Over the years consumer behavior studies relied on observing the consumer navigation and interaction patterns in the real world, and the process included a large number of activities including:

- tracking the users while they were shopping to satisfy there needs
- using numerous cameras in the shopping centers
- Or even trying to capture the consumer's eye movements!

All these activities are very expensive, time consuming, and the information provided is neither sufficient nor reliable, and since people need to have privacy and space in order to purchase their needs. These activities made consumers annoyed and uncomfortable. Our main aim is to provide the optimal solution to the consumer behavior studies nightmare; we plan to enhance the productivity of these studies by utilizing the 3D virtual space and its technologies.

6.2 project description:

The first step is:

- **Building the 3D model:**

We have decided to build the 3D model using 3ds max 6.0 since it is proven to be one of the best 3d builders; the model represents a shopping location (mall), figure 6.1 shows the primary mall design.

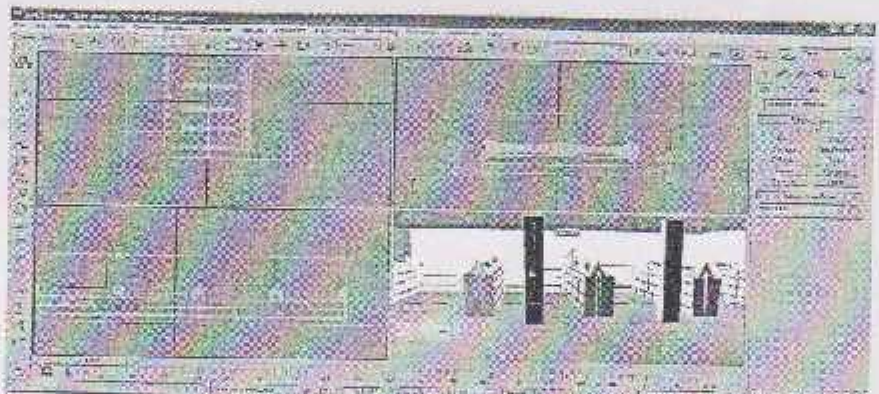


Figure 6.1 primary mall designs on 3ds max

To provide high level of realism we used a combination of real world and virtual environment components, the real world components include: the physical characteristics of the model (space division, lights, camera and vision properties), and 2D images of real products. Real world 2D products were customized using adobe-Photoshop CS.

The model is shaped as a four walls room, the space inside is divided into three sections using shelves, shelves are also placed on the mall rooms, all the shelves included in the model are filled with 2D products, the products are organized on the shelves based on their categories and common use . Figure 6.2 demonstrates how we used Anim8or for adding materials 3D shelves

Figure 6.2: adding material with Anim8or

The shelves after customization and material editing are presented in figure 6.3

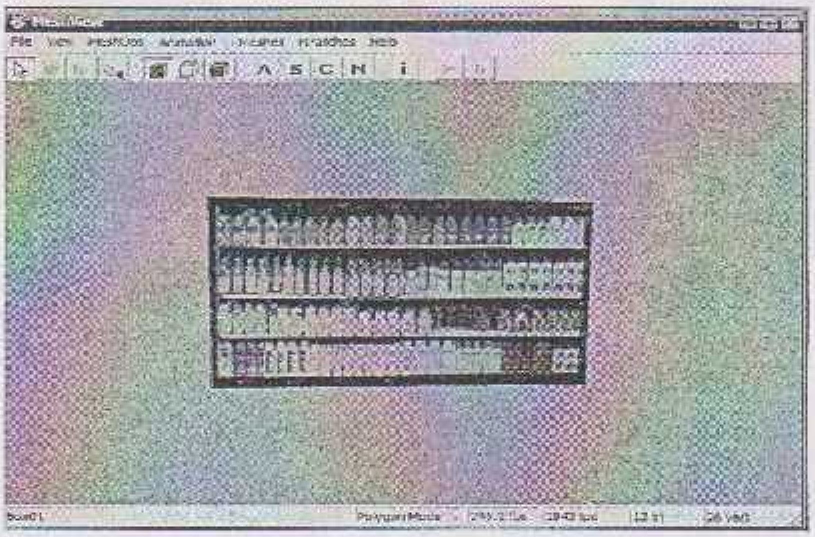


Figure 6.3: 3D virtual shelf

In order to enable vision all over the mall we used built in lights, lights were not the only thing necessary to provide vision we needed to set some cameras in the location and we had to position them in the right places to make sure that the camera views included all the model components. After setting lights and cameras we placed some ads on the models walls. The result was a 3D model with a high sense of realism and user friendly virtual environment

While Figure 6.4 shows some view of the virtual shopping location which we have created ,figure 6.5 shows some views of a tangible shopping location there is a huge resemblance between the virtual model views and the tangible ones in our world ,in fact were able to provide a significant degree of realism to the virtual model .

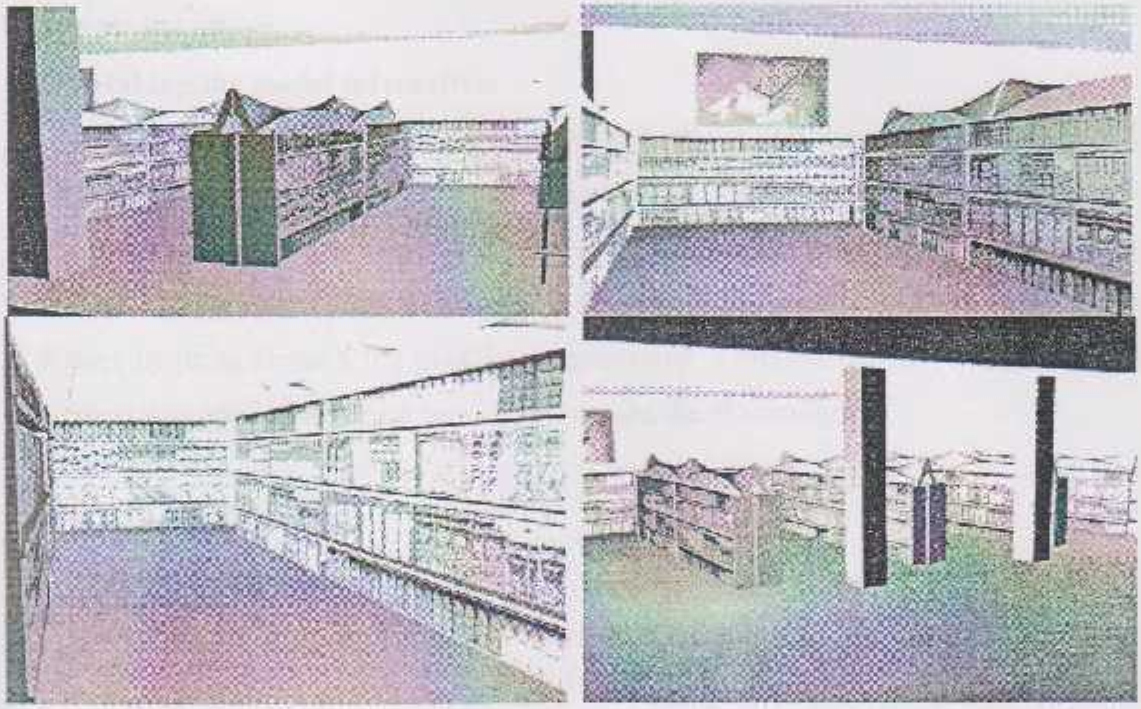


Figure 6.4: views from the virtual shopping location

Figure 6.5: view from a tangible shopping center

The second step is:

- **Making the model interactive:**

The 3D model should be interactive and allow consumers to freely navigate throughout the model, real time consumers can navigate in the model by using the traditional keyboard, and they will be able to explore the environment and examine the available products and carry out their daily work as in real world. we acquired this feature by using DirectX 9.0 SDK in programming a method called OnKeyDown ,the method was applied to the c# form that contains the 3D model.

The next step is:

- **Allowing consumer tracking:**

We used c# and DirectX 9.0 SDK in programming all the necessary methods, classes and functions to enable consumer tracking, the combination of c# and DirectX 9.0 SDK is the best combination that support tracking at real time in a 3d environment . What w did is the following:

While consumers are navigating through the model the system tracks their movements in real time, each movement from the consumers side is captured by the system, the system understands the consumer movement from one location to another in the form of [location (x, y, z)], afterwards the locations are saved to a file related to the consumer who made the movement. We can actually draw a line that reveals the consumer track, and the system tracking information visually as seen in Figure 6.5

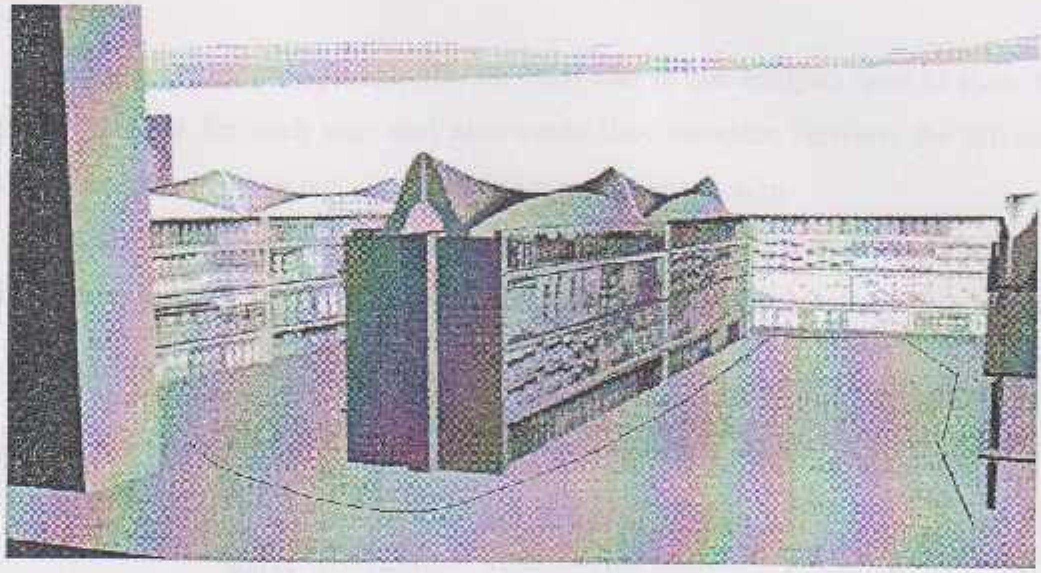


Figure 6.6: user track in the shopping location

The last step is:

- **Saving and collecting information:**

The location related information for each user whom the system tracked is saved into files. Each user will name a file and enter his personal profile before actually *entering the shopping location. figure 6.7 shows the form* that enables us to create a single file for each user .

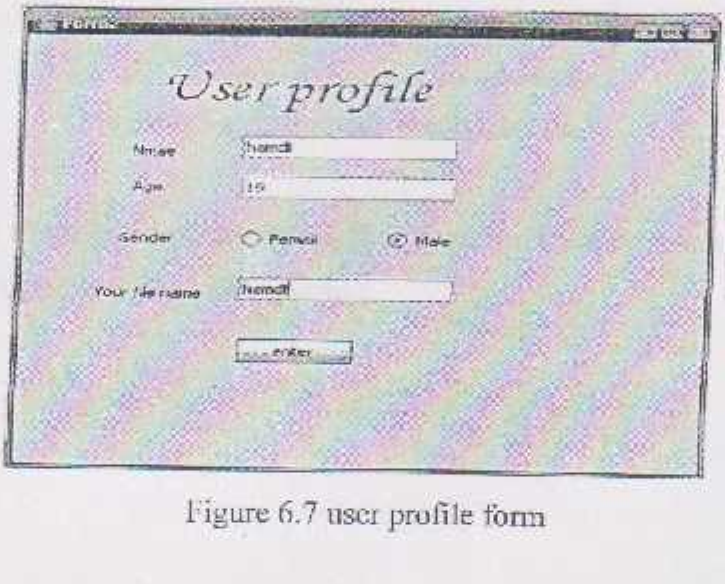


Figure 6.7 user profile form

The reason behind using single file for each user is that analysts need to study the behavior patterns for each user and afterwards they compare between the different behavior patterns to come out with valuable result or conclusion

At the end of the experiment each consumer profile file is filled with his information and saved for analytical studies future usage. Figure 6.8 shows the results file for each user

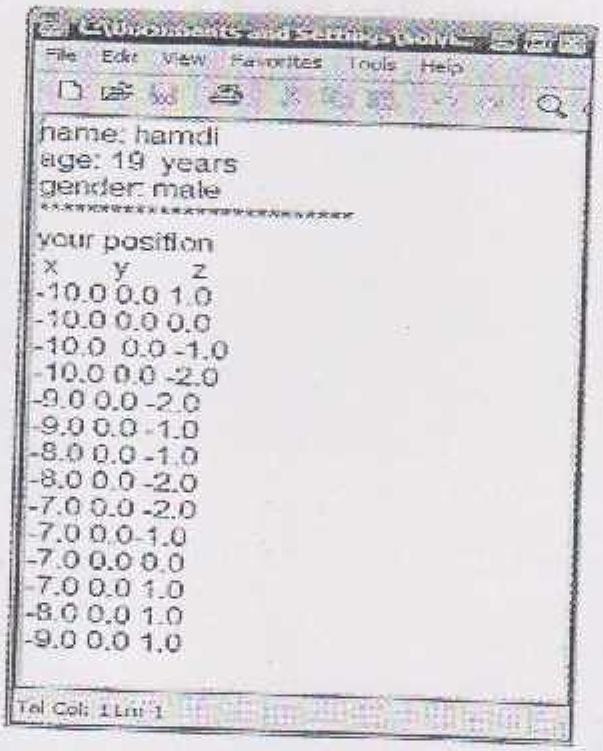


Figure 6.8 a consumer trace results file

At the end of the shopping experiments all the consumer tracking result files can be collected and saved for analytical future usage.

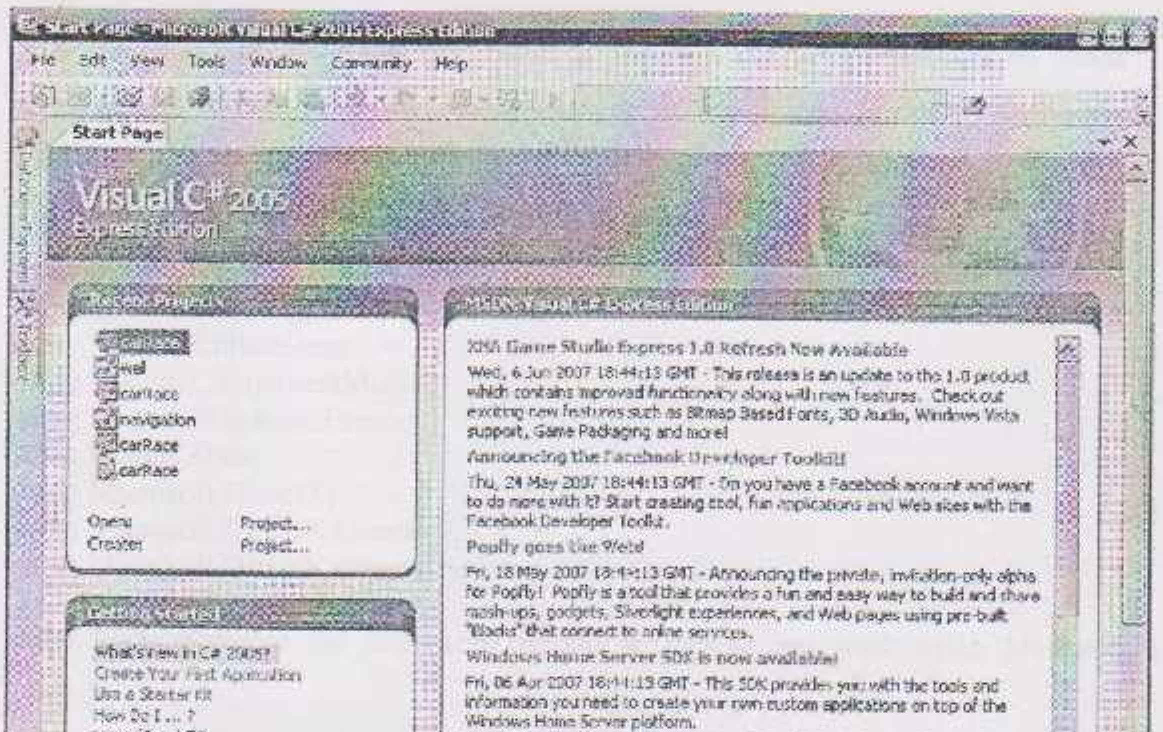
Chapter Seven
Implementation

7.1 Project implementation:

In this chapter we will focus on the functions that we used in our programmed experiment, we will explain each function, method, and device we used to compete our work.

The main steps in our experiment implementation are:

We needed a source code editor and a runtime environment. We were recommended to use Visual Studio.NET 2005, as that is what Microsoft supports figure 7.1 shows the c# start page window.



Next we installed the DirectX 9.0 SDK Update developer runtime. We were recommending installing the DirectX 9.0 Software Development Kit before we started the development of our Managed Direct3D application; we needed to get our environment ready. To accomplish this we followed these steps:

1. The first thing we did was loading Visual Studio.NET and creating a new project.
2. We selected the Visual C# projects area, and created a new Windows Application project. We needed a place to do our rendering, and the standard Windows Form that comes with this project works perfectly.

After the project is created, we made sure that Managed DirectX references are added to the project so we can use the components, so we had to open the code window for the main windows form in our application (by default form1.cs) and add the following lines:

```
using System;
using System.Drawing;
using System.Collections;
using System.ComponentModel;
using System.Windows.Forms;
using System.Data;
using Microsoft.DirectX;
using Microsoft.DirectX.Direct3D;
using Microsoft.DirectX.PrivateImplementationDetails;
```

these lines represent the references needed to present our work using Managed DirectX .

The root of all drawing in Direct3D is the device class. To Create our device we used the following code:

```
device = new Device(0, DeviceType.Hardware
, this.Handle, flags, presentParams);
```

The device parameters do the following:

"Adapter" refers to which physical device we want this class to represent, Adapter 0 is always the default device, The next argument, DeviceType, tells Direct3D what type of device we want to create. The most common value used here is DeviceType.Hardware, which means that we will use a hardware device.

The next parameter is used to control aspects of the device's behavior after creation. Most of the members of the CreateFlags enumeration can be combined to allow multiple behaviors to be set at once

The last parameter of this constructor controls how the device presents its data to the screen, The windowed member is a Boolean value used to determine whether the device is in full screen mode (false), or windowed mode (true).

The next step is to add a new function to our class called "InitializeGraphics" that will be where we can actually use the constructor (device) we've discussed before. The following code describes the function:

```
Public void InitializeGraphics()
{

// Set our presentation parameters
PresentParameters presentParams = new PresentParameters();

presentParams.Windowed = true;
presentParams.SwapEffect = SwapEffect.Discard;

// include our Create device code
device = new Device(0, DeviceType.Hardware, this,
CreateFlags.SoftwareVertexProcessing, presentParams);
}
```

Then we declared our main method as follow static void Main()

```
{
   using (Form1 frm = new Form1())
   {
      // Show our form and initialize our graphics engine
      frm.Show();
      frm.InitializeGraphics();
      Application.Run(frm);
   }
}
```

the using statement around the creation of our form. This ensures that our form is disposed when the application leaves the scope of this block. Next, we added the Show command to the form. We do this to ensure that the window is actually loaded and displayed before we try to create our device. We then call our function to handle our device creation, and use the standard run method for our application.

Then we used the following method:

```
this.SetStyle(ControlStyles.AllPaintingInWmPaint | ControlStyles.Opaque, true
```

to easily fix changing the "style" of the window we created.

Now we have a screen window with the needed device and parameters, the next step is to Setup our camera position and parameters to enable visualization on the windowed application the following code does the work :

```
private void SetupCamera()

  device.Transform.Projection = Matrix.PerspectiveFovLH((float)Math.PI / 4,

      this.Width / this.Height, 1.0f, 100.0f);

  device.Transform.View = Matrix.LookAtLH(new Vector3(0,0, 5.0f), new
Vector3(),

      new Vector3(0,1,0));
```

The three parameters in the device.Transform.View method represent the camera location, target and level of height above the ground.

Now we can actually run the application exceprt yet there is nothing to see, we need to load the 3D model with its materials and textures, to do so we used the following function:

```
public static Mesh LoadMesh(Device device, string file, ref Material[] meshMaterials,ref Texture[] meshTextures)
```

to Load our mesh

```
Mesh.FromFile(file,MeshFlags.Managed, device, out mtrl);
```

to load our materials,we first need to store them

```
meshMaterials = new Material[mtrl.Length];
meshTextures = new Texture[mtrl.Length];
```

In order to get our model texture, and load it

```
TextureLoader.FromFile(device,mtrl[i].TextureFilename);
```

In Managed DirectX the 3d models are known as meshes,Now our mesh is actually on the windowed application but it still needs some lighting to lighten our mesh we add the following light property :

```
device.Lights[0].Enabled = true;
```

now we can actually see the mesh on the application window the last step to coplete our experamentprogramming code is to apply the interactive properties to the application and aapply the save into file function

we used the OnKeyDown method

the following code represent one sample of the code needed to complete the work :

```
protected override void OnKeyDown(KeyEventArgs e)

  {
    if (e.KeyCode == Keys.L)
    { capture the movement actionand save into file  }
```

Chapter Eight
Results, Conclusion and Future work

8.1 Results:

After four months of searching, studying and analyzing the magnificent technology of real time consumer tracing in a 3D virtual environment we proved the following:

- There are numerous advantages for using virtual environments rather than tangible environments in the case of consumer behavior studies.

In fact VEs allows advanced understanding of physical space also it enables the shopping locations decision makers to make wiser choices in the case of physical locations arrangement and design and in their product arrangement criteria.

- Real time object tracking in a 3d virtual environment provides reliable and consistent information regarding consumers purchase patterns.
- Real time object tracking in a 3d virtual environment allows the visualization of user flow in a certain shopping location
- This technique is proven to be more convenient and comforting for consumers, and at the same time it is proven to be more efficient and reliable for decision makers and consumer behavior analysts.
- After conducting an interview with Hebron mall shopping center manager we are certain that this technology will provide significant improvements to the way consumer needs are met and provided, that means consumers will be pleased and the management will have more profits to gain.

The following figures show the mount of information we were able to collect from a virtual consumers shopping activities:

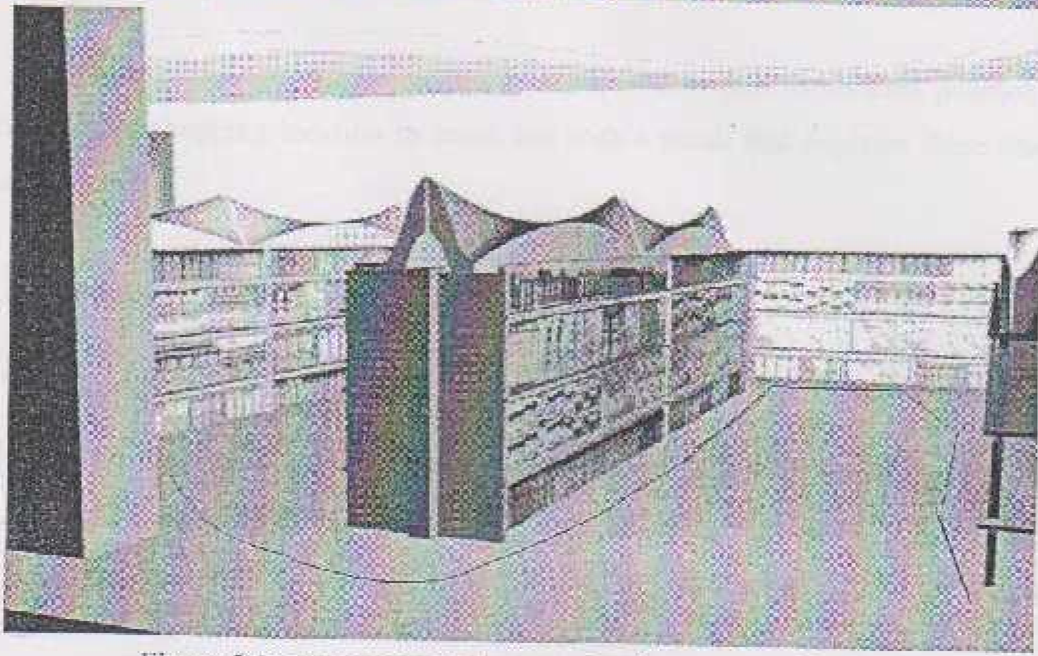


Figure 8.1: consumers tracks are visually presented in the VE

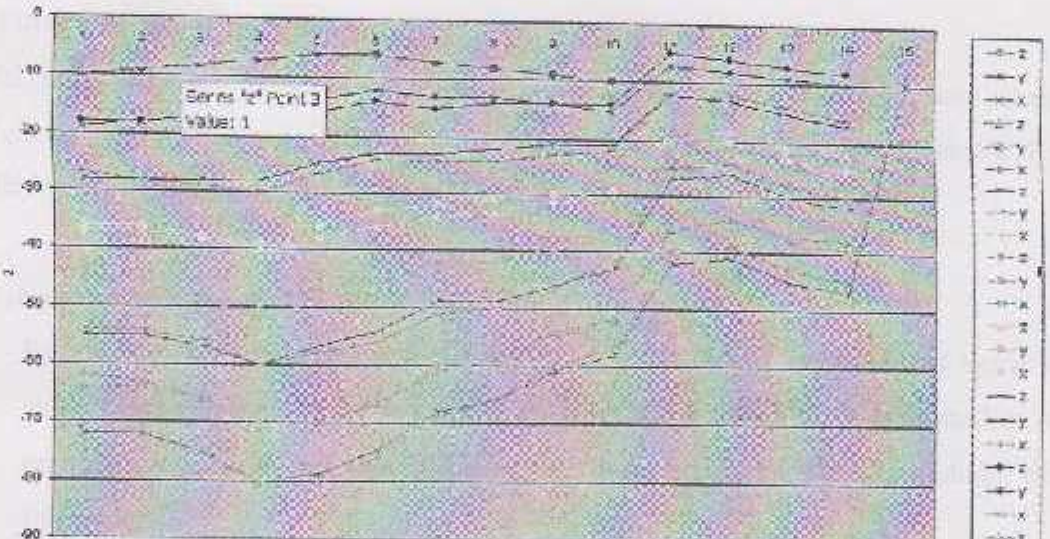


Figure 8.2: consumer's location information chart

Figure 8.2 shows the coordinates of the track which consumers walked in while performing their purchase activities, as you can see we can locate the most visited positions on the shopping location by analyzing the coordinates provided in the figure ,we can also highlight the less visited locations .

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