



## HCI Techniques interacting with a 3D environment for representing web search results

### Técnicas de HCI en Interacción con un Entorno 3D para la Representación de los Resultados de la Búsqueda Web

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#### Abstract

Searching for information through the World Wide Web is a common task nowadays. However, it is mostly a textual experience. This work proposes and implements a 3D environment for representing Web search results in a three-dimensional (3D) environment that is controlled by gestures and speech recognition. In order to do that, two scenarios are required: a server-side solution based on XML Web Services that allows being consumed by clients that are searching information on the Web; and one client-side application that allows being executed as a graphic user interface in desktop by using speech and gesture commands. This latter application is in charge of graphically modeling the 3D environment according to the Web search results. A prototype of the proposed system, which represents a set of Web search results in a 3D environment, was implemented. The 3D scenario is handled by gestures and voice commands; the 3D environment is based on the management of some 3D transformations such as rotation and scaling of the inner faces of a torus. An evaluation of the prototype in search contexts suggests that there is a high level of user acceptance of

the proposed multimedia model. Testers have said that the prototype has an intuitive graphical user interface, and that both speech and gesture recognition have been a highly functional alternative for tasks related with Web searching. Still, there are some aspects to improve, especially in the speech recognition support of different accents. Overall, the multimedia prototype met the expectations from a sample of end users, showing that such interfaces have great potential.

**Palabras clave:** results, web search results, HCI, gesture recognition, speech recognition, 3D environment.

#### Resumen

La búsqueda de información a través de la World Wide Web es una tarea común hoy en día. Sin embargo, es sobre todo una experiencia textual. Este trabajo propone e implementa un entorno 3D para la representación de los resultados de búsqueda Web en un entorno en tres dimensiones (3D) que es controlada por gestos y reconocimiento de voz. Con el fin de hacer eso, se requieren dos escenarios: una solución de servidor basado en Servicios Web XML que permite

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ser consumidos por los clientes que están buscando información en la Web; y una aplicación en cliente que permite ser ejecutado como una interfaz gráfica de usuario en el escritorio mediante el uso de comandos de voz y gestos. Esta última aplicación se encarga de modelar gráficamente el entorno 3D de acuerdo con los resultados de búsqueda Web.

Un prototipo del sistema propuesto fue implementado, lo que representa un conjunto de resultados de búsqueda Web en un entorno 3D. El escenario 3D es manejada por gestos y comandos de voz; el entorno 3D se basa en la administración de algunas transformaciones 3D tales como la rotación y el escalado de las caras interiores de un toroide.

Una evaluación del prototipo en contextos de búsqueda sugiere que hay un alto nivel de aceptación del usuario del modelo multimedia propuesto. Las personas que probaron el prototipo han dicho que tiene una interfaz gráfica de usuario intuitiva, y que tanto el habla como el reconocimiento de gestos han sido una alternativa altamente funcional para las tareas relacionadas con la búsqueda Web. Sin embargo, hay algunos aspectos a mejorar, sobre todo en el apoyo de reconocimiento de voz de diferentes acentos. En general, el prototipo multimedia cumplió con las expectativas de una muestra de los usuarios finales, lo que demuestra que este tipo de interfaces tienen un gran potencial.

**Keywords:** resultados, búsqueda web, HCI, reconocimiento de gestos, reconocimiento de voz, entorno 3D.

## 1. INTRODUCCIÓN

The force of habit makes that human beings repeat each day the tasks without a reflection on how to do these tasks; one of those daily tasks is Web searching for information. Traditionally, a person types a text (search criteria) and then a Web search engine produces a list of links for navigation. But, are there another ways to do a Web search in terms of usability? This work proposes and explores an alternative way about how to search for information on the Web by articulating technological adaptations from the

domain of Human-Computer Interaction and specifically from the field of Natural User Interfaces. With this in mind, a 3D environment for representing Web search results using speech and gesture recognition is proposed, designed, implemented and tested.

### 1.1 Problem Statement

Despite technological advances, the way that people look for information on the Web is practically the same as they did from the WWW service startup. In summary, a textual search query is given, and then, a set of Web results is provided by a search engine as a list of links. On the other hand, Human Computer Interaction (HCI) Techniques have an enormous potential in terms of adaptation or innovation of computing solutions; however, their implementation has been focused in computer games and some computing solutions for the disabled.

Considering the advancements in multimedia technology, the creation of new ways to interact with Web search engines is something to worthwhile explore. This is the field of action for this work, in order to adapt HCI techniques in scenarios with a traditional functionality, such as Web searching.

### 1.2 Scope

Within the proposal of a 3D environment for representing Web search results, a prototype is needed for meeting the requirements in matter of functionality; this is due to the mechanisms incorporated for speech and gesture recognition as a response for an alternative style for Web searching. With this idea, the scope of the work covers the elaboration of a proposed 3D environment for modeling Web search results in a 3D scenario; in addition, such 3D environment is tested through the creation of a prototype which incorporates speech and gesture recognition in order to handle the 3D scenario.

Taking into account this scope, it is important to emphasize that this work is not a complete system; but merely provides a theoretical framework proposed in the company of a prototype for evaluation purposes.

### 1.3 Approach and Methodology

Within the research scope, this work belongs to the quantitative approach in the frame of empirical-analytical studies. In terms of methodology, this work used both the experiment and the survey methods. The election of such research methods was driven by the essence of natural and applied sciences about measuring and demonstration [1]. The experiment was based in proving the stated hypothesis through the implementation of the 3D environment via a prototype. Thus, the survey method allowed measuring the usability degree of that prototype. For building the prototype, a software process was required. According to the features of the proposed solution, a prototype lifecycle was the main guideline in its construction. So, the chosen prototype lifecycle is based on the proposal of Bennet, McRobb, and Farmer, which it is shown in Figure 1.

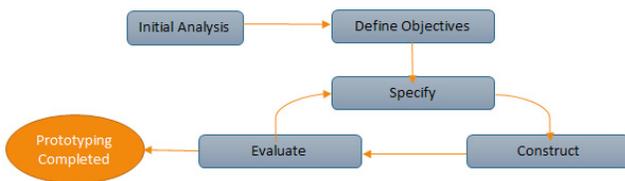


Figure 1. A prototyping lifecycle [2].

## 2. BACKGROUND AND LITERATURE REVIEW

Practically all kind of information is on the Web nowadays. According to this, millions of people use technological devices (such as PCs, laptops, smartphones, and so on) to get information on the Internet via the World Wide Web service. According to the History, the Web was born in Switzerland (specifically in the CERN labs) in 1989 when Tim Berners-Lee created the Web bases with the aim of sharing information among researchers. It was the introduction of web which facilitated the expansion of the Internet to allow a more attractive and accessible network. This began to happen in 1993, the year when about 150 websites worldwide were available. Since those times, the way how people search for information on the Web has been based on the usage

of specific programs (software on client) called browsers. With these programs, a Web search engine is reached in order to type search criteria; then a result set is generated in a form of links. Today (more than 20 years after the Web's inception), the panorama is exactly the same: "Using a Web browser, the computer program of software that lets you access the World Wide Web ... When you type a keyword or phrase into a form and click on a button or icon on the screen, a list of items appears." [3].

Consequently, the way how people search for information on the Web is considered as the current paradigm since the point of view of computing. For most end users, such paradigm is ok and few reflections are done on the way how the Web search results are represented. In a similar form, these common everyday activities are rarely analyzed, such as the gesture of shaking hands to greet in most cultures around the world. This gesture is so common that few people reflect on how to do this action.

All starts with a concept coined inside the domain of Human Computer Interaction (HCI), technology, such concept is Natural User Interface (NUI). But, what is the main idea behind the NUI concept? Well, the notion about something "Natural" comes from the "real word"; where human beings interact in a traditional way as they do the things in real life. Then, taking into account this principle, the main idea behind the NUI points toward how people can leverage the potential of new technologies to better their own capabilities [4]. In this order of ideas, default graphic user interfaces have permitted the development of software applications for all contexts; however, the way how the end user interacts with the software (and computers of course) belongs to an existing and predominant paradigm. This is the action field of NUI; where it is necessary to explore alternative ways to deal with technology.

In a preliminary review about researches in matter of HCI-based technologies in common tasks of daily life, new hardware devices have been developed in order to interact with end users in different ways. Current systems based on speech and gesture recognition have had an enormous application in

entertainment environments such as video games; in this vein, some companies in the game industry have developed alternative ways to play their products, including motion controllers, voice commands and gesture capture, among others.

Historically, several companies developed their technologies around the NUI concept. Nonetheless it is important to do a special emphasis in a specific project that brought such concept to impressive levels: the Microsoft's "Project Natal". This project is based on the usage of a motion-sensing device (now known as Kinect Sensor) which was designed exclusively for the XBOX 360 gaming console. In that context, "one of the distinguishing factors that makes this device stand out among others in this genre is that it is not a hand-controlled device, but rather detects your body position, motion, and voice" [5]. According to this features in terms of functionality, Kinect Sensor is a good tool for developing HCI-based application by using speech and gesture commands.

In spite of its initial intention for gaming, these hardware devices have a huge potential in terms of usability in different scenarios. Boulos et al. [6] stated in their background review HCI-based techniques that can be used for conferencing purposes, for diagnosing mental disorders in children, for telepresence in surgery procedures, even for visual effects in marketing and publicity. In similar terms, Warade [7] proposes new ways for training by using Kinect cameras.

Talking about gestures, Project Mudra worked on natural interfaces for replacing the mouse's movements and its actions [8]. In the same way, a novel way to replace the computer's mouse was proposed by Mangalindan [9] through Kinect camera. In addition, in the Economist there was an interesting report about a research project that worked with Microsoft Kinect in order to become portable the computing solutions by using light projections, and infra-red positioning in hands and fingertips.

On the other hand, Newby [10] explores a novel way to represent information in 3D environments for information retrieval tasks. It constitutes into

an important first step for this project's intention. In addition, several examples about new ways to represent information and retrieve data within the topics of computer vision are provided by a series of workshops and conferences [11]. In the same topic about representing information in three-dimensional environments, Japanese researchers proposed at the end of the 20th century a 3D browsing space where the "time coordinate" is present in the visualization of information. They represent a hierarchical space for browsing information in a graphic way; to do that, items in the space must be related in a structured way in order to create series of planes in the 3D environment [12].

In technical terms, an excellent resource of information about how to work with speech recognition and gesture capture by using Microsoft Kinect is the electronic book written by Kean et al. [13]. This new book provides a complete reference for programmers in order to construct robust systems based on Microsoft Kinect.

Talking about HCI innovations, a novel project led by the Leap Motion shows how a HCI device can be used to command computer applications by gestures. In this vein, that enterprise has developed a hardware device that tracks the user's hand movement in front of the HD monitor [14]. In spite of the enormous benefits for HCI-based applications, Leap Motion controller is exclusively focused on user's hands; with this, it cannot track the entire human body, and it does not recognize voice commands either.

Regarding Web search and Web browsing, an important issue is presented when end users have some kind of disabilities. In such context, alternative ways for doing Web searches and then exploring their results must be proposed; this is the case of an interesting project called WebTree. WebTree promotes the use of Web search and browsing in a different way according to the current paradigm 'type a text and get a list of links'; with this, such project proposes a simple user scenario for representing Web-based documents into a tree-structured interface [15]. In addition, Web search results can be also filtered

according to some special mark-up tags; where it is considered an interesting contribution in terms of Web search.

On the way of looking for new alternatives in Web browsing, several contributions can be highlighted such as 3D Web Browsing experiences by SpaceTime 3D [16] and iFree3D [17]. Both web sites provide a fresh experience in 3D for Web browsing tasks; they were built by using Adobe Flash. For those sites, it is required to have experience in navigating within 3D environments; in addition, they are embedded solutions in HTML pages; which implies the usage of a Web browser.

An interesting work related with gesture-based web browsing using Microsoft Kinect was done in the MIT Media Lab. This experience contemplated the use of gestures in order to navigate in a customized web browser; in addition, it was included functionalities in open tabs for selecting links, browsing history, scrolling, zooming, and panning. That project is called DepthJS which is available in the official web site of MIT Media Lab (<http://depthjs.media.mit.edu/>). An important contribution of DepthJS is the strong support in JavaScript for the usage of Microsoft Kinect, which implies an enormous potential in terms of portability in Web environments of such device [18].

In relation with Web browsing, Microsoft Corporation announced on June 2012 the new implementation of its Web Browser Internet Explorer within the game console Microsoft Xbox 360. For this particular case, the experience of browsing the Web will be available by using voice commands in the game console [19]. In spite of the novel approach, navigation tasks are practically the same in the sense of giving search criteria and browsing Web results as a manner of list of links.

Currently, people are immersed in a world where 3D technology and augmented reality environments have led to the traditional use of keyboard and computer mouse as obsolete functionalities. Now, new trends about the usage of human senses are conceived as an alternative way to interact with computers. In this vein, specialized technology about

speech recognition, writing recognition, touchable interfaces, movement recognition, and visual recognition among others are part of the new strategies for enabling user interaction with computing solutions. Revolutionary ideas are emerging on enabling new ways to control or manipulate computer programs. Such is the case of the technology called MYO Armband which allows controlling computing application by sensing the arm's muscles. This device lets people "use the electrical activity in their muscles to wirelessly control a computer, phone, and other favorite digital technologies" [20].

Since Kinect, Leap Motion, and even MYO Armband, all these technologies require physical movements from a human being. But there is a new horizon in terms of controlling computing solution with no physical movements: this is called Neural User Interfaces, which implies the usage of the power of thinking to control something.

Perhaps, the best sample of such technology is presented as Neural Impulse Actuators (NIA). NIA producers have incorporated an electro-myogram, an electro-encephalogram and electro-oculogram in a headband and a central processing unit with USB connections [21]. With this, no more physical movements will be required to control something in a computing solution. In a strict evaluation of this product, there is a paper that established a set of reference parameters for measuring how effective is NIA; according to the findings, NIA requires a good phase for training and currently NIA can be accepted for gamers in first instance [22].

With these experiences, Sci-Fi is closely related with these times where technology is becoming into reality lots of previous ideas in matter of user interaction with computing solutions.

### 3. THE SIMPLIFIED MODEL FOR THE PROTOTYPE PRODUCTION

A 3D environment was conceived in order to implement the higher-level idea, somewhat theoretical at this point, due to lack of functional consumer hardware. This 3D model implements the high-level

idea using existing tools and technologies in a very similar manner to the higher-level idea.

In this process and implementation, firstly, a user provides the search criteria through voice commands; then, a Web search engine is consumed in order to get the information according to such search criteria; finally, Web search results are represented graphically in a 3D environment where gesture commands are in charge of exploration tasks.

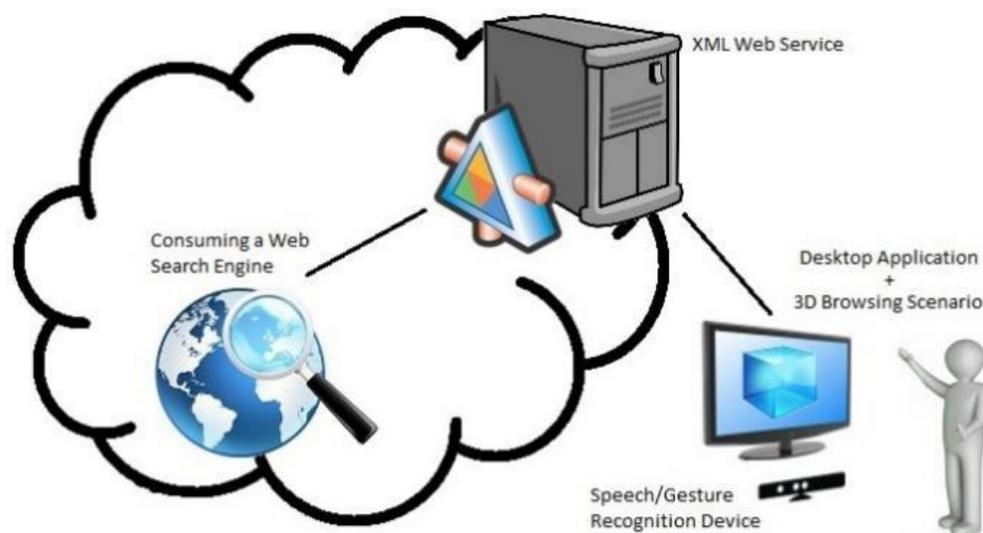
In a graphic manner, Figure 2 shows how the prototype works in two main scenarios: The World Wide Web with a customized XML Web Service, and a desktop solution.

In short, the proposed solution based on a prototype interacts with a Web search engine in order to obtain sets of results. Communication between the World Wide Web and the proposed solution is managed via a customized XML Web Service. Finally, the “visible” part of the solution, that interacts with the end user directly, is implemented as a desktop application; for such scenario, a speech/gesture recognition device can be connected with the desktop application if the user wants such functionality (this means that the prototype works with or without the special device, the device is optional only for the speech and gesture recognition).

It is important to note that a specific Application Programming Interface (API) for searching in the Web was consumed. In technical terms, Google Search API was consumed in order to articulate the feature of Web searching into the prototype. In the exploration for new alternatives in matter of handling Web search results; this work proposes a 3D environment to represent those results in a 3D scenario. In addition, the graphic is managed by voice commands and gesture recognition.

In order to cover all the aspects related with this work, the following list of activities was planned: learn the state-of-the-art of finding and handling information on the Web by using HCI-based techniques, establish a set of voice and gestures commands in order to find and handle information from a Web search engine, design a 3D environment for handling Web search results, design an appropriate framework, build software components for the prototype, execute software tests and a usability study, analyze results, and write the work’s report.

At this point, all the items above were developed. It is relevant to mention that the creation of the 3D environment was the work’s main goal. In this vein, such 3D environment was tested in real environments through a prototype. It stands to



**Figure 2.** Simplified Model for the prototyped solution (own source).

reason that the creation of the prototype involved a software process; in this matter, a prototyping lifecycle was used.

### 3.1 System Architecture

Due to the specific features of the proposed system, a prototype will be developed and implemented for certain client environments; these are based on the Microsoft Windows OS family for desktops. In this vein, a layered architecture is used in accordance with the features related with hardware devices and development/deployment platforms for the Desktop Application. Sommerville stated that a layered architecture provides a good scenario to make portable the computing solutions; however, “only the inner, machine-dependent layers need to be re-implemented to take account of the facilities of a different operating system...” [23].

In response to the general requirements, the entire system must work on two scenarios, a desktop one and a Web-based one. That’s why Figure 3 shows two architectural stacks for the mentioned scenarios. In short words, the desktop scenario is in charge of modeling the 3D environment and the rendering process of the websites’ screenshots; the server

scenario provides the resources for enabling Web searches by consuming a professional API for such functionality.

According to the System Architecture, for both scenarios, the desktop and the web service, will use Microsoft technology for the deployment platform. The lower layers (HCI Device and WWW Environment) are part of the pre-established technology which will be required for the prototype functionality. In contrast, the upper layers represent the major development effort in the desktop application and the XML Web service as well.

At this stage, a general view was conceived in accordance with the main idea stated above: it is necessary to create a prototype that implements the proposed 3D environment for Web searching with NUI-based techniques. Taking into account that some components are already available in the development platforms via SDKs, Software Development Kits, some classes in the Analysis and Design stages are consumed only. Thus, the classes related with 3D engines, speech recognition training and gesture recognition are consumed but they are not defined in terms of programming. The specification of the analysis and design provides a global idea about how the final implementation should work.

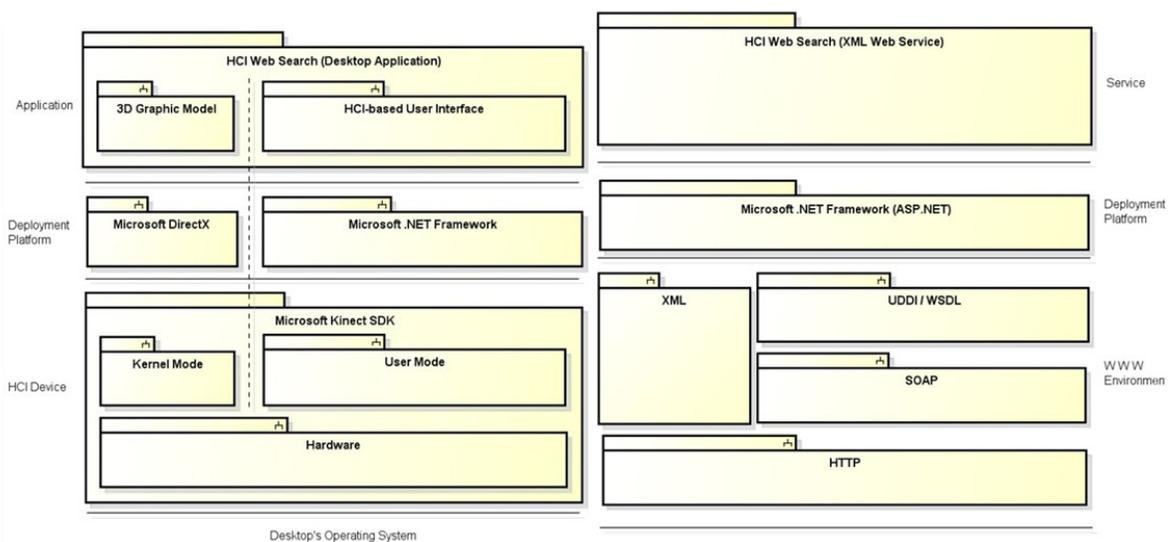


Figure 3. System Architecture (own source).

### 3.2 Designing the gesture-based commands

Basically there are a set of actions that were programmed via gesture recognition; such actions are: swipe to the left. Swipe to the right, zoom in, and zoom out. The technique used for recognizing gestures is based on positional comparison of hands, bows and the center of the shoulders. In this vein, Table 1 and Figure 4 present the information for the set gestures.

### 3.3 Establishing the voice commands

Table 2 shows the set of voice commands which were programmed for the prototype; in such table is related the voice command and the method that is fired by such command.

The infrastructure for recognizing speech command is provided by the speech recognition system embedded in the Windows 7 operating system. In programming, it was consumed the namespace SpeechLib which is derivated of the dynamic link library called Interop.SpeechLib.dll for such purpose.

**Table 2.** Set of voice commands (own source).

VOICE COMMAND	METHOD TO FIRE
"navigate"	this.Navigate();
"search"	this.WantToSearch();
"go"	this.Seach();
"cancel"	this.Cancel();
"yes"	this.Exit();
"no"	this.DoNotExit();
"exit"	this.WantToExit();

### Designing the graphic scenario

Firstly, it is necessary to establish the 3D scenario where the Web search results will be modeled. With this in mind, a three-dimensional model is required in order to be imported in Extensible Application Markup Language (XAML) for rendering the scenario by using the Microsoft DirectX resources on Windows Presentation Foundation. The 3D Model was created in Blender 2.67b for Windows (64-bit), and the result can be seen in Figure 5.

**Table 1.** Set of gestures (own source).

Action	Condition	Graphic Reference
Swipe to Left	if RightHand.Y < RightElbow.Y and RightHand.X < ShoulderCenter.X	
Swipe to Right	if LeftHand.Y < LeftElbow.Y and LeftHand.X > ShoulderCenter.X	
Zoom In	if RightHand.Y < RightElbow.Y and LeftHand.Y < LeftElbow.Y and RightHand.X > RightElbow.X and LeftHand.X < LeftElbow.X	
Zoom Out	if RightHand.Y < RightElbow.Y and LeftHand.Y < LeftElbow.Y and RightHand.X < RightElbow.X and LeftHand.X > LeftElbow.X	
Reset Gesture(hands down)	if LeftHand.Y > LeftElbow.Y and RightHand.Y > RightElbow.Y	

In the following photos there are people interacting with the prototype. It is shown in Figure 6. As a description about how the prototype works, users can use speech commands to give directions about the web search. The prototype gets the input

from the user and then perform a web search by using an API for such purpose. Finally, the prototype renders the web results in the inner faces of a torus that can be manipulated by gesture commands. Some screenshots are shown in figure 7.

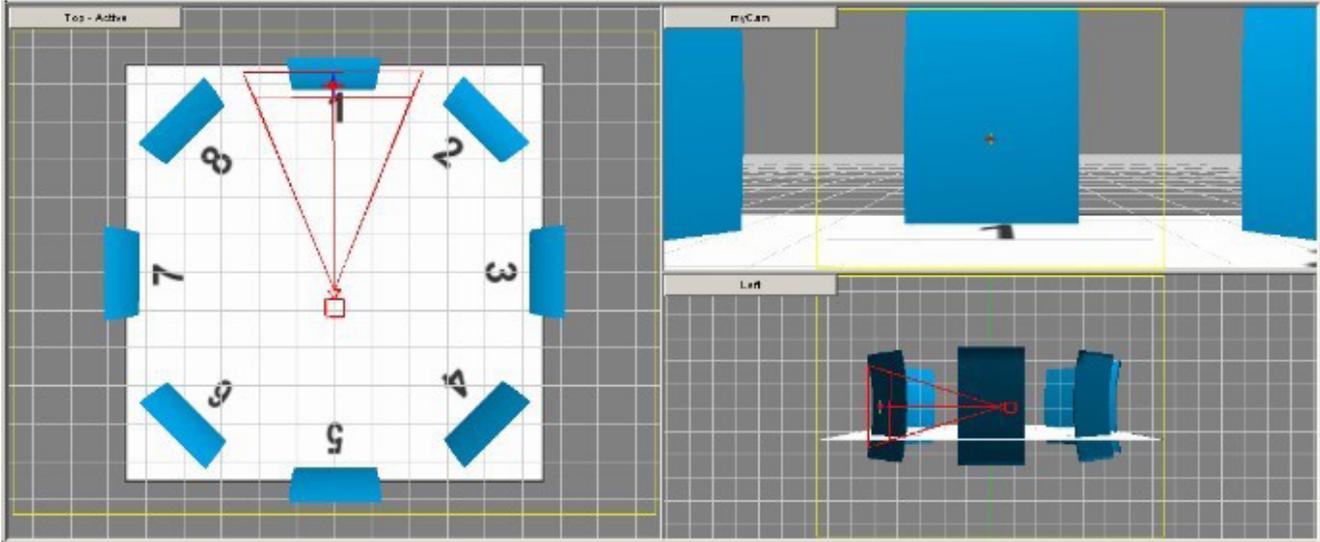


Figure 5. The 3D environment for the prototype (own source).



Figure 6. People interacting with the prototype (own source).



**Figure 7.** Screenshots about how the prototype works (own source).

#### 4. CONCLUSIONS

This work shows that it is feasible to handle Web search results by using gesture and speech recognition in a three-dimensional 3D environment. In addition, such functionalities provide a good user experience in matter of usability; however, the speech recognition requires good conditions in the scenario where is available. Given this, the hypothesis has been proved.

According to the findings, they suggest that the proposed 3D environment has a good level of acceptance by the end users. Testers considered that the proposed user interface is easy-to-use and highly intuitive. In this vein, programming Web search tasks which are supported by speech and gesture recognition is not a difficult labor if the design of the user interface is well conducted in terms of usability. User interfaces based on gesture and speech recognition are technological adaptations, which are familiar for most of the end users. In the specific case of this prototype, practically the preliminary instruction was not required; testers just saw a practical example done by the work's author, and that was all what they needed.

Rendering process of the websites' screenshots is the bottleneck in matter of representing the Web search results for this prototype. The delay in rendering is due to the dependency with the Internet connection and the load time of a website in a Web browser's engine for rendering purposes.

Speech recognition activities require a preliminary phase of training. In addition, the acoustic conditions of the environment are a relevant factor at the moment of recognizing spoken words and entire sentences. Fortunately, with the use of special devices for audio such as microphones on headsets can improve meaningfully the quality of the recognition process.

#### 5. FUTURE WORK

Some projects could be oriented to the migration of this prototype toward other platforms apart of the Microsoft's, such as Mac, Android, Linux, Solaris, among others. These actions might allow the creation of new proposals for improving the Web browsing experience. However, this involves great efforts in programming due to lack of drivers and SDKs for some platforms mentioned above. Still, the internal logic in the coding of activities on the functionality of the prototype can be highly reused and reinterpreted in other software construction scenarios.

In conclusion, this is a modest contribution to the generation of alternative ways for representing Web search results using natural user interfaces. This contribution was made using a proposed 3D environment that was implemented in a prototype, which the viability was assessed using a usability test with favorable results.

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