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Graphical interfaces for development exploiting the third dimension using Kinect

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Abstract. The use of graphical interfaces for software development is discussed in this paper and a novel framework is proposed introducing the concept of 3D interaction during the implementation. The implications of 3D programming are explored focusing on 3D databases and their representation as long as possible uses and issues. Experiments were performed to validate the proposed system and further to indicate the importance of using three dimensions in the development systems.

Keywords. Human computer interaction, programming and developing interfaces.

Introduction

The contemporary graphical interfaces have evolved from the typical console-based writing code to visual programming environments, where the programmer can interact with the components required to create new applications, but there is still a remaining non-graphical component in the interaction. Also, those components are not advanced enough to provide the necessary flexibility and clarity to understand many aspects of the development that could be better acquired with a full graphical user interface. These problems become more obvious in pure graphic applications, which need a better understanding of the environment where the tools will actually work [1].

Research to improve interaction with computers has become one of the main issues during the last twenty years (or more) and many advances have been made. During the SIGGRAPH panel of 1998 [2], researchers addressed the importance of developing a new way to establish a communication between humans and computers. The new computer systems had to be capable to capture all the ways of communication that the human being is able to use and integrating more senses (not just vision) in interaction with software. The need of making the hardware more integrated with the work environment is necessary to improve the users' experience, making more natural the computer aided process, (e.g. in industrial design). Researchers presented approaches to break the barrier between a natural interface and a typical "device" interface.

Advances in hardware and software integration have created new ways to interact with machines. Essentially, those advances are aimed to improve human-computer interfaces and their main objective is to make these more natural, based on understanding body motion, gestures and sensory integration; and able to understand more than just

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written commands [3]. The area that is really thrusting the advances in interaction is the video game industry due to the need to provide new levels of experiences and much higher interaction between the users and the systems. Also, much of the video game innovation has been used in scientific areas (i.e. as graphic processors, interaction devices, tracking algorithms, body motion capture, etc.), both in terms of new hardware, and making that technology accessible to common people [4].

The level of detail in the interaction environment is regarded important too. Create the connection between the graphic metaphor and the data to be manipulated [5] can be problematic as well and is highly dependent of the context. In a 3D framework, the developer has to create the software layers for the specific components, including the connection graphic elements with data and the interaction language [6]. Then, the developer has to create the objects that are going to be used as basic programming elements, flexible enough to develop new applications [7].

The gesture based systems are related to hand gesture controls and they become very popular nowadays, especially in hand-held portable systems such as laptops, mobile phones and gaming devices [8]. In many cases just having a two dimensional interaction is not enough to perform naturally specific tasks, especially when these activities are performed in three dimensions in everyday life. Advances in depth capturing devices provided novel approaches to interface systems, as Microsoft Kinect has shown lately [9].

This paper presents the results of our studies on the field of 3D hand gesture interaction and how this approach can improve the developers experience and speed exploring the advantages of using a natural human computer interface. The proposed methodology solves some of the most problematic issues in this area such interaction in 3D space using finger tracking, gesture-functionality identification and recognition. Based on our analytical and empirical work the proposed framework suggests a viable alternative to conventional techniques since it provides unrevealed possibilities to design, develop, monitor, access, test and debug software, which otherwise would be very difficult to perform in a two dimensional environment.

In this paper, we propose the use of three dimensions in software development and results are presented for the case of database programming. In section 2 we briefly present some previous work on the subject of human-computer interaction.

1. Previous work

The development of new interface paradigms in the last years made apparent the need to advance the interaction approaches with information. The work of Ratti in the MIT's Tangible Media Group [10] presents an alternative to replacing the text-driven systems in geographic information systems (GIS). This new approach permits interacting with geographical data, where the user can modify the interface using tangible objects, (such as blocks, trees, hills, etc.), integrated with augmented reality environments. Furthermore, the work presents two different alternatives to implement that system: Illuminating Clay and SandScape. Illuminating Clay uses a laser based scanner to capture a physical clay model using triangulation. SanScape, instead, uses infrared illumination beneath the surface; the interaction with the surface is captured with a monochrome infrared camera and the feedback can be seen in the surface thanks to a projector above the surface. These systems were tested in a real urban design course in MIT and the results showed that this kind of systems can make the designers work easier and faster. The big problem of implementing this kind of interfaces is the high cost of the devices used and the difficulty to configure all the hardware and software for a single application. Also, the usability tests were not performed in a real industrial environment.

The 3D representation for data is not just for simple and small systems. The possibility to represent in 3D large amount of information is explored exhaustively in the work of Markus [11], where the representation of a large software system using 3D models allows a better understanding of high dimensional data. The most relevant aspect of this system is related to the user interaction and 3D visualization, allowing visualization of different nest levels in the code. Each element represents a code segment (i.e. represented as containers) or information sources (i.e. represented as poly cylinders) mixed in a map that can be manipulated and viewed in different positions, getting even the possibility of views in 2D. The major drawback of this particular design is that the interaction is still based in 2D and that traditional devices are used keeping the disadvantages of a 2D interaction in a 3D environment. The interaction results are still limited in this model of representation and the use of more complex manipulation commands or multiple combinations of them depends on traditional interaction methods.

Another issue that should be considered is how the data will be visualized by the developer. For an environment that aims to be more natural for the user, the better option seems to present the virtual environment in 3D, allowing further manipulation corresponding to the specific scene for a given environment (metaphor). The creation of this environment is important, and the lack of tools to generate that kind of interfaces increases the difficulty. The work of Esnault in [12], addresses the problem of how future Web3D can be generated, reusing design experiences and doing a good separation between the data and its representation. The approach used by Esnault is to divide the system in two big substructures: the Genotype, a structuring metaphor construction which contains all the logical elements, such as data structure definition, the model of the exploration of the information and the access to the data source; and the Phenotype, which defines the visual aspect of the metaphor construction and the 3D visualization of the interfaces. In that case all the system is based on style sheet techniques, web-based components and an intensive use of XML. The separation presented allows strong reusability of both components in future systems. The big drawback of the proposed solution is the lack of tools to develop the 3D environment. The interface has to be created using common 2D elements in typical development systems. Also, the system proposed for the 3D environment is just for web interaction and it is not developed for natural interaction systems.

An interesting perspective was introduced by the use of modern video game devices, initially developed for entertainment, but because of their 3D detection capabilities, are used in several other applications. The most well-known cases are the infrared detection based devices, especially Microsoft Kinect. The work presented by Tang [13] related the Kinect utilization for hand gesture recognition and in [14] Frati proposed to use the same device in the field of wearable haptic technology (i.e. as a compensation for the lack of sensibility of the wearable haptic devices). This technology allows the recognition of hands and fingers for specific tasks. The only drawback of these approaches are that the tasks presented in their works, mainly are oriented to the manipulation of simple image scenarios in a graphic 3D environment, but not aiming to a higher level of interaction.

In the next section we present a novel 3D database programming environment based on 3D gesture interactions utilizing Kinect as an interface. Novel metaphors are proposed designed for 3D databases improving the development speed and the level of perception. A specific example is presented where a query is designed for a 3D database, trying to select raw and time data associated with gestures. Furthermore, the novel 3D interaction mechanisms with the information are analyzed, presenting the initial concept, novel applications and the actual construction of these software models.

2. 3D data interaction

The contemporary graphical interfaces have evolved from the typical console-based writing code to visual environments, where the user can interact with the components required to create new applications. In the current human-computer interaction systems, there are still non-graphical elements, which could be replaced by better iconic representations of information. Also, those components are not advanced enough to provide the necessary flexibility and clarity to understand many aspects of the represented information. That could be improved and better acquired with a 3D graphical user interface. Some aspects of data could be more clear if the metaphor is included as part of the representation [15]. Additionally, some connections between 2D data representations as a 3D object could improve their understanding and functionality. Interaction with data is nowadays limited to traditional 2D environments and representations. Also, if there is a graphic representation of information, they contain just few graphic definitions (e.g. tables or data sheets), but these interface systems are not enough interactive and natural [16].

2.1. 3D Databases

The multidimensional representation of information is not a new area [17]. There have been multiple efforts associated with managing databases in more than two dimensions to improve the search/retrieve of information and data modeling [18]. These representations of the information are based on the On-Line Analytical Processing (OLAP) and the same for all the derivations to construct databases, queries and data mining. One as aspect that is interesting related to 3D databases is the cube modeling and all the possible applications of that model. The possibility to represent multiple sources of information as a unique tri-dimensional entity provides the ability to manage data that could be impossible in a traditional interpretation, allowing relationship management and mapping of “hidden” information [19]. Actually all these models are managed under traditional interfaces, creating and manipulating all those models just using line commands and simple graphic representations (e.g. disconnected tables). Instead using a graphic 3D model to represent those data cubes seems to be the most natural way to interact with them. A 3D representation of those cubes will provide a better understanding of how the information in “each side” is related as a whole concept and the possibility of visually interacting with this cube (i.e. selecting rows, rotating sides and retrieving information using just gesture based interaction) will increase the productivity and efficiency in manipulating and modeling all these type of entities.

2.2. Robot Programming

Robot development and programming is a research area related to multiple fields and technologies. The main aim of robot programming is to make them perform specific tasks in the simplest way, mainly because the use of robots is not only a privilege of experts nowadays. Visual controls to manipulate specific functions of robots are popular and largely used because they provide several advantages in the manipulation of specific components and functions, such as displacement and articulation movements [20]. Even that several graphical interaction tools have been created, they still use traditional interaction techniques with all the drawbacks associated to the limited unnatural interaction methodologies. A gesture-based programming approach can improve this task, especially in humanoid robots, where the interaction needs to be really close to the human way to react, act, and interact [21].

2.3. Development of 3D electrical systems in buildings

The modeling and development of an electric system are issues studied in [22] due to the increasing need of making them more efficient and reliable. Using 3D components that resemble the real ones, including the possibility of integrating critical structural information will provide several points of view and prevent possible risks. Also, the integration with specific devices, like climate control systems, in a 3D environment can also speed up the construction of new buildings [23]. A gesture based system could certainly improve the collaborative and interdisciplinary work, highly necessary in the construction and planning of electrical systems for large edifications.

3. Proposed Methodology

The proposed methodology attempts to define a novel way to create a common structure for different kinds of 3D hand gesture based applications. This methodology comes from our previous work to define a common developing framework for two handed gesture interaction in 3D environments [16]. In this approach, the application is divided in several layers, each of them with specific tasks. The layer architecture and the connection between their components can be seen in Figure 1.

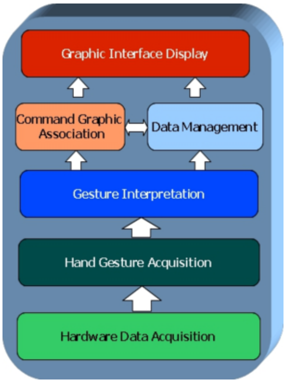

Figure 1. Layer architecture for two-handed gesture based systems.

The base layer of the proposed systems is related with the data acquisition and the hardware needed to perform this task. In this layer, all the APIs and drivers are placed. For our study case, we use Microsoft Kinect because of the features that provide in the human posture/movement detection. The depth detection is crucial in order to perform 3D activities, necessary for natural 3D interaction. The next layer is related to the identification of the hand gesture, which in our case is related to the hand and fingers identification. The gesture interpretation is the layer responsible to "translate" the gesture into a specific command, strictly related to the interaction environment. Command graphic association and data management take control of the actions and the state change of the environment. Performing a gesture triggers a subsequent action and the graphic interface display shows the result of the interaction. This architecture provides the flexibility to define several kinds of applications based on 3D interaction. Also, it can provide a high degree of hardware independence.

Considering this architecture, there are some specific issues we should consider in our experiments, based on 3D interaction databases. These aspects are discussed below:

3.1. Finger tracking

This aspect is relevant to a hand-gesture based interaction, because our system gestures are based on the hand and finger correlation and their differences. The detection of the hand is based on the depth map proportioned by Kinect® device, under the usage of OpenNI ® drivers and SDK to connect the device to a normal computer and the possibility of gather data directly from the device and get some specific information (such as palm hands position) . The interactive environment was programmed in C# using WPF for the graphic design and 3D modeling; all developed using Microsoft Visual Studio 2010. The detection of the hand's contour relies on the segmenting the depth map at specific distance. In order to identify each hand, the relative position in the detection space is considered. The system uses an approach similar to the one presented by Frati [24] to perform the detection of the fingers. Each finger is detected by identifying the end points and their convexity. Each end point represents a finger, but also, the palm location provides information about the relative 3D position of each finger in the hand. However, since the detection of the hand is provided by segmentation, it lacks the problems of the hand gesture/detections of the work presented by Tang [13]. In that work the detection of each hand depends on the distance from the sensor (infrared), on occlusions and possible reflection problems. Also, the hands are detected as independent elements, not connected with the whole body, which limits the range of detection, but provides more degrees of freedom and gesture recognition speed. Experimentally, the optimal distance between the user and the Kinect® device should be approximately between 60 and 90 centimeters for and optimal hand and finger detection and ideally, the movements should be performed in parallel to the device.

3.2. The interaction

The interaction in our model is based only on "pure" hand-gestures, which means the interface is using the hand and no other "device" is involved to perform the tasks. This hand-gesture interaction is based on the number/position of the fingers and their changes will generate different actions and constantly different responses by the system. For our basic model, one hand indicates the function or mode and the other hand will perform the action itself. Considering that, the interactions will be divided in three groups:

- Movements: These actions correspond to changes in the position and/or orientation of 3D graphic elements in the environment.
- Selections: The selections are related to choosing or highlighting specific 3D elements or components and parts of them.
- Executions: Interaction related with triggering an action could be the result of a combination of the previous ones or a new separate hand gesture.

3.3. 3D Databases

3D databases are a derivation of multidimensional databases as explained previously. In our case, we consider the cube database. These kinds of databases provide an interesting field of research development due to the several data mining features offered by this model [3]. This kinds of databases are useful in cases where the relationship between different pieces of data are not totally clear and it is necessary to connect several information sources, which cannot be performed by traditional 2D databases. A clear example of that is related to medical information, where the need to find association between factors not obviously related could help to improve the patient attention and diagnosis. In that example, hidden health factors and possible causes of diseases and sickness could be shown. However, because of the complexity of the traditional model, we defined a novel one that resembles the functionality, but with a simplified approach, where the cube is formed by multiple tables related between them.

4. Experiments and Results

In order to evaluate and test the proposed methodology experiments using a simplified version of a 3D cube database was performed. A hand-gesture interactive system was developed to compare this approach of writing specific queries with a traditional SQL set of sentences. The relevant elements of this experiment are explained below:

4.1. The interface

The experimental interface to test our proposed methodology was a 3D data interaction model. A simplified model of a cube database with the two faces of the cube representing information about a group of patients was developed. The test interface model can be seen in Figure 2.

Figure 2. Data Cube model.

One of the faces contains basic identification information of the patients. The other face has information about their weight over time. The top face of the cube gives the possibility to close the application. The rest of the faces of the cube contain the same close button than the top face. This simplification was applied to avoid confusing the users of 3D interfaces and test a limited interaction. Additionally in this particular example of 3D databases only two sides of a cube are required to fully describe the relationships, but more complex datasets could be represented using either more faces or other models.

The user is able to interact with this cube using both hands. The left hand is used as function indicator and the right hand performs the action on the screen. This configuration was decided to limit possible confusions between actions. The “indicator” finger is depicted by the cursor, indicating the exact position on the screen and the cube. Any other combination of hand/fingers will not produce any result in the interface.

There are 3 types of interactions:

- I Rotation: The cube can be rotated from left to right and vice versa. In order to make the interface more intuitive only two faces of the cube are accessible, the front face (with the patients' personal information) and the right side (with the weight/month information). This action is performed by keeping the left hand open and the movement action is performed by moving one finger of the right hand from left to right or vice versa, depending on the face that the user wants to see. There is no rotation on the horizontal axis.

- Selection: Users must display two fingers of their left hand and placing the moving finger over an element to select it.
- Clicking: The user must remain in selection mode (two fingers of the left hand) to access this mode. In order to perform the clicking, the indicator finger must be placed over a selectable element and "push" (move forward, towards the screen).

In our implementation the selectable elements of the cube are the button "close", the column headers and the rows. To select a full column, it is just necessary to click on the column header.

Each of these movements has thresholds to avoid considering as actions random movements. Also, the full interface have indicators to facilitate each task, such as the "function mode" indicator which shows the function mode, the action performed and the column (if it is necessary) where the action is being performed.

4.2. The Experiment

In our experiment the simulation of a simple information selection from two tables is performed. In this specific case, the user is asked to select the name and the weight information during July and August. There is no specific order in the selection, but the combination of these three columns is needed for each face of the cube. This aspect eliminates the possibility of "random" performance of the task.

The general idea is to show the user the possibility of a graphical query over a traditional SQL query and obtain information about the advantages and disadvantages related to the performance of that process. Also, qualitative information over the usability of the interface and the general user satisfaction is obtained. The idea to compare a cube 3D interface with an SQL query resides in the general concept of data manipulation, access and retrieval over a 3D environment that traditionally has been under 2D domains. Also, the cube interface configuration suits with a 3D hand-gesture based interface, because an interface of this type resembles aspects of the real world.

To improve the human computer interaction feedback according the proposed task was provided. The full interface for the experiment can be seen in Figure 3.

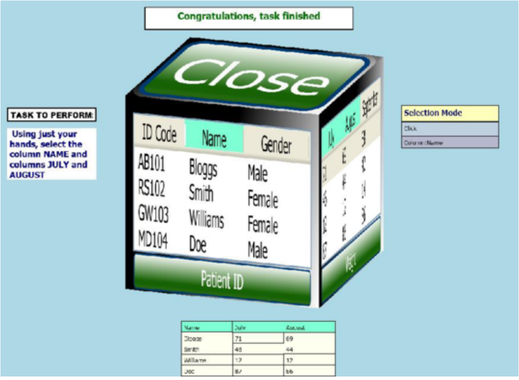

Figure 3. Full Interface.

4.3. Procedure of the experiment

The experiment was divided into six steps, presented below.

- Details and objectives: The objective of this experiment is to gather information about the possibility of using a hand gesture interface instead of the traditional SQL code to perform queries on a 3D database.
- Demonstration: The aim of this section is to present to the users the interface and its elements, answering any related questions. Also, if the user is not familiar with SQL, the basics of the language will be explained.
- Familiarize the subject with the interface: During the familiarization stage with the interface, interaction with the interface will be presented allowing the user to practice.
- Subject performs the available functionalities: The available functions (e.g. rotate, click) will be explained and performed by the user.
- Perform the full task: Once the user familiarize himself with the environment and with how to perform the available functions, then the full task will be performed counting the required time to accomplice it.
- Complete the questionnaire: After the completion of the task, a questionnaire about this experience is provided, evaluating and comparing the available interfaces (i.e. visual and SQL).

The sequence of interaction can be seen in figure 4.

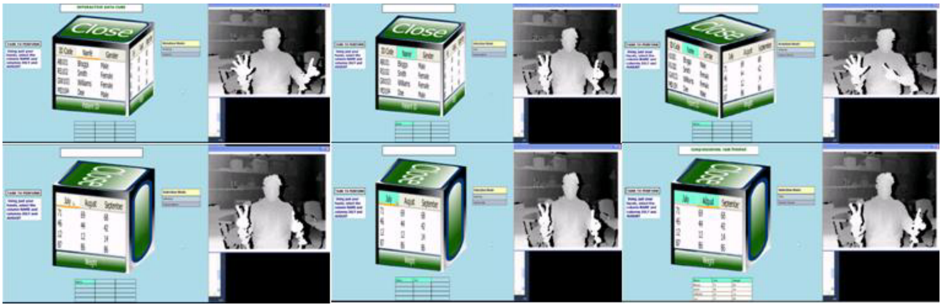

Figure 4. Experiment interaction sequence

4.4. Questionnaire Analysis

The result of the experiment is directly evaluated by the summarized information collected by the questionnaire. The construction was based on the usability model presented by Lewis [24] and the questions been divided into 3 sections, with a range from 1 (extremely bad) to 5 (extremely good). Twenty students and professionals in the computer science field participated, and further details were collected such as the age, the time to perform the task, gender and knowledge of SQL or not. The sections of the questionnaire are described in table 1.

Table 1. Questions by section from usability questionnaire

Section 1	**Section 2 - How would you rate:**	**Section 3- SQL interface compared with the proposed visual approach**
Was the interaction easy to understand?	The Interface?	The selection is easier than SQL?
Was it easy to **manipulate?**	The Performance?	The task is more intuitive than SQL sentences?
Is the navigation system intuitive?	The functionality?	Is it easier to learn the proposed visual approach than SQL?
	The objective achieved?	Is the task faster to perform than with SQL?
	The user experience?	
	The hand gestures selected?	

4.5. Obtained Results

The results are presented below and the significant points are related to the "external" information, the questions, the performance time and the correlation between them.

Table 2. Average results and deviation values by section

SECTION	***Q1***	***Q2***		***Q3***	
Average	**4.5**	3.2		3.9	
Deviation	0.69	0.62		0.81	
SECTION	***Q4***	***Q5***	***Q6***	***Q7***	***Q8***
Average	**4.0**	3.4	3.8	**4.2**	3.8
Deviation	0.73	0.75	0.72	0.7	0.91
SECTION	Q9	Q10	Q11	Q12	Q13
Average	3.9	4.0	4.3	3.4	3.9
Deviation	0.93	0.79	0.72	1.27	0.93

In the tables 2 to 4 the obtained average scores for the answered questionnaires are showed. As it can be seen, for the first section, the main positive point for the user is related with how easy is to understand the interaction. Also, the interface obtained the higher points along with the possibility to achieve the task properly. In comparison with SQL, the system presents really strong points in the intuitive use and the learning simplicity. Also, it is relevant that any answer had an average punctuation not lower than 3 (normal).

The time performance is another important parameter to analyze. Some graphics presented below showing how different aspects are related to the speed and the time to accomplice the tasks.

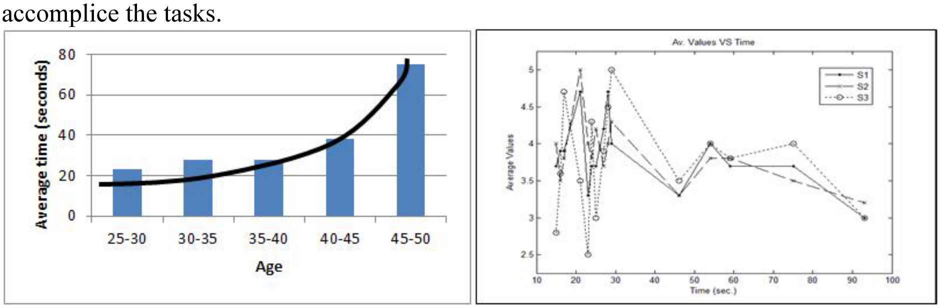

Figure 5. Performance of the subjects according their age & scores per section VS performance time

The age of the users seems to be a factor related to the required time for using this interface, because, as can be seen, people younger than 40 years old resulted the best times. This is especially clear with the subjects below 30s, as it can be seen from the curve that better interaction times were obtained in general compared with the elder people. The performance difference is more pronounced as we move to subjects about 40s following an exponential function.

The satisfaction level seems not to be an important point in relation to the time required to perform the actions. The following graphs demonstrate this observation.

The performance does not vary significantly relative to the preference for the interface, but in the three sections, the people that were more satisfied seems to be also faster.

Finally, the gender and the knowing of SQL show some interesting results.

Table 3. Average time and age for males (75% of the subjects), females (25% of the subjects), people who knew sql (70% of the subjects) and people who did not know (30% of the subjects)

	Male	***Female***	***SQL***	***No SQL***
Av. Time	33.47	30.2	33.57	30.5
Av. Age	36.07	31	33.57	36.33

The difference in performance time seems to be minimal, but it is observed that females and people that declares not knowing SQL seem to be fastest than males and people who knows SQL. From the obtained results it is shown that the knowledge of SQL is not an advantage in the manipulation and interaction with 3D environments. This is also part of the aims of this novel programming approach that tried to make the system easy to use without having requiring any programming knowledge of SQL or being an advantage.

5. Conclusions

In this work a novel 3D based interface for software development was proposed. A set of interaction methodologies was analyzed and discussed indicating that some applications require the third dimension to exploit all the available interaction techniques.

In order to evaluate and validate the proposed system qualitative experiments were performed focused on 3D database design and development. The system was developed using Kinect and capturing the fingers of the user. From the obtained results it can be observed that using a 3D representation for that kind of applications can significantly improve the user experience and improve the development speed. Also, this approach seems represent better the representation and interconnection of data elements, allowing a better understanding of the information.

Future work on this area will be focused in improve some aspects of interaction and selection of data process in the 3D interface presented. Different interaction approaches will be tested and evaluated trying to improve the HCI. Also, other modalities will be used to support more complex tasks such as advanced commands related to database programming or other development areas.

References

[1] M. Rotard, D. Weiskopf and T. Ertl, “A combined introductory course on human-computer interaction and computer graphics”, *Computers & Graphics* **29**(2005), 267-272.

[2] M. Harris, B. Buxton, W.T. Freeman, H. Ishii, M. Lucente and M.J. Sinclair, "Interfaces for humans (panel): natural interaction, tangible data, and beyond", SIGGRAPH 98 Conference abstracts and applications, 1998, 200-202.

[3] A.F. Blackwell., "Dealing with new cognitive dimensions" in *Workshop on Cognitive Dimensions: Strengthening the Cognitive Dimensions Research Community*., University of Hertfordshire, 2000.

[4] P. Barr, J. Noble and R. Biddle, '"Video game values: Human-computer interaction and games" *Interactive Computers* **19-2**(2007) , 180-195.

[5] M. Wu and R. Balakrishnan, "Multi-finger and whole hand gestural interaction techniques for multi-user tabletop displays" *ACM Special Interest Group on Computer Graphics and Interactive Techniques* (2003), 193-202.

[6] K.P. Fishkin, "A taxonomy for and analysis of tangible interfaces", *Personal and Ubiquitous Computing*, **8-55**(2004), 347-358.

[7] M. Conway, S. Audia, T. Burnette, D. Cosgrove and K. Christiansen, "Alice: lessons learned from building a 3D system for novices" *Proceedings of the SIGCHI conference on Human factors in computing systems* (2000), 486-493.

[8] Y. Boussemart, F. Rioux, F. Rudzicz, M. Wozniewski and J.R. Cooperstock, "A framework for 3D visualisation and manipulation in an immersive space using an untethered bimanual gestural interface", *Proceedings of the ACM symposium on Virtual reality software and technology*(2004), 162-165.

[9] E. Guettard, S. Jandziak , C. Lombard , N. Podevin , V. Varane , P. Dumont ,"Virtual reality from the keyboard/mouse couple to Kinect", *Annals of Physical and Rehabilitation Medicine*, **54**(2011), pp. 239.

[10] C. Ratti, Y. Wang, H. Ishii, B. Piper and D. Frenchman, "Tangible User Interfaces (TUIs): a novel paradigm for GIS", 2004, vol. 8, no. 4, pp. 407-421. 2004, vol. 8, no. 4, pp. 407-421. Transactions in GIS, 2004, vol. 8, no. 4, pp. 407-421.

[11] MARCUS, A., FENG, L. AND MALETIC, J.I " 3D representations for software visualization" *In Proceedings of the 2003 ACM symposium on Software visualization*, 27-ff.

[12] N. Esnault, J. Royan, R. Cozot and C. Bouville, "A flexible framework to personalize 3D web users experience", *Proceedings of the 15th International Conference on Web 3D Technology*,(2010), 35-44.

[13] M. Tang, "Recognizing hand gestures with microsoft's kinect," Web Site: http://www.stanford.edu/class/ee368/Project_11/Reports/Tang_Hand_Gesture_Recognition.pdf., 2011.

[14] V. Frati and D. Prattichizzo, "Using Kinect for hand tracking and rendering in wearable haptics", *IEEE World Haptics Conference* (2011), 317-321.

[15] L. Chittaro, R. Ranon and L. Ieronutti, "3D object arrangement for novice users: the effectiveness of combining a first-person and a map view", *Proceedings of the 16th ACM Symposium on Virtual Reality Software and Technology* (2009), . 171-178.

[16] R.A.H. Acuna, C. Fidas, V. Argyriou and S.A. Velastin, "Toward a Two-Handed Gesture-Based Visual 3D Interactive Object-Oriented Environment for Software Development," *Proceedings of the 8th International Conference on Intelligent Environments* (2012), 359-362.

[17] K. Stefanidis, G. Koutrika and E. Pitoura, "A survey on representation, composition and application of preferences in database systems", *ACM Trans.Database Syst*, 36-4(2001).

[18] R. Agrawal, A. Gupta and S. Sarawagi, "Modeling multidimensional databases", *Proceedings of 13th. Int. Conf. On Data Engineering (ICDE)(* 1997),. 232-243.

[19] P. Vassiliadis, "Modeling multidimensional databases, cubes and cube operations", *Proceedings of the 10th International Conference on Scientific and Statistical Database Management* (1998), 53-62.

[20] P.I. Corke, "Visual control of robot manipulators-a review," *Visual servoing* **7** (1994), 1-31.

[21] T. Kanda, H. Ishiguro, T. Ono, M. Imai and R. Nakatsu, "Development and evaluation of an interactive humanoid robot" IEEE Proceedings **2**, 1848-1855

[22] W.H. Kersting, "Distribution system modeling and analysis", (2012).

[23] F. Oldewurtel, D. Gyalistras, M. Gwerder, C.N. Jones, A. Parisio, V. Stauch, B. Lehmann and M. Morari, "Increasing energy efficiency in building climate control using weather forecasts and model predictive control" *RHEVA World Congress* (2010) , 9-12.

[24] J.R. Lewis, "IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use", *International Journal of Human - Computer Interaction* **7-1**(1993), 57-78.