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M-learning Enhancement Using 3D Worlds*

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As mobile-learning evolves, it needs an increasing amount of information to be displayed in the device screens. Also, to develop applications to be currently used by a wide range of users, the target devices must be the mobile phones rather than PDA or bigger devices. As the phone screen is very small and many different contents must be shown, a new approach is needed to join both requirements. This paper presents a proposal for the use of 3D worlds to enhance the interface of mobile-learning applications. Some specific test results are shown for every component available to construct 3D worlds. The result is an expanded interface where more information is displayed in the same space related to the subjective 3D perspective.

Keywords: mobile learning; m-learning; PDA; 3D technologies

INTRODUCTION

MOBILE-LEARNING INITIATIVES usually face problems that lead to failure or little success. Some of these problems are objective, since they are real and do not depend on personal evaluation. Other problems are subjective, because their relevance is very small although users do not think so. As a global result of many medium or hardly successful initiatives developed in the field of e-learning and m-learning, we concluded that it is not fair to consider all potential users of m-learning tools or systems as a group due to the impossibility of obtaining general characteristics that represent every group of users. As the number of users is increasing, the number of groups is getting bigger and the necessity of selecting and studying a particular group as a destination of the developed tools are apparent.

In this work, the target is a group of engineering students who may perform at the highest levels of success because of their personal preferences in a daily use of technological tools and devices. In other words, it is the perfect population due to the fact that they use them for learning and they learn to use them. We expect that the obtained results will shed some light so as to extend the benefits of mobile learning to other groups. Future research would be carried out with similar groups as working engineers or other technically qualified workers.

The possibilities of m-learning are growing as fast as the speed of networks and the capabilities of the PDA and mobile phones. So, the initiatives which may be implemented must be used by a substantial percentage of the destination population [1]. In order to obtain this, it is necessary to consider that buying a PDA is not an option for most of the students because of its high cost and the limited usefulness they can get from it. Then, the only available option is to use mobile phones as target hardware for the developed tool and to avoid creating marvellous applications whose aim is only to be tested in some research team who own PDAs, or to be tested in student groups specifically created to run the test.

The use of phones to develop a tool for m-learning is a real challenge due to the shape of keyboards and screens available [2], as well as the low processing and memory capabilities. There are many initiatives trying to enhance the hardware which can only be made by phone manufactures who can deal with these limitations. Nevertheless, in this paper we try to enhance the interface using software techniques, with which we get an expanded displayed space available to develop the m-learning tools using 3D API to convert the 2D surface shown on the screen.

To implement 3D tools using a phone implies creating low-weight worlds with small images and with limitations in the number and size of the contents. A typical configuration available in a medium-class phone contains a display from 208×208 pixels (Nokia 6230i) to 128×128 (Nokia 6822) with 65.535 colours. Many phones included in this category only have 176×208 pixels displays. Figure 1 presents a real measure of these sizes comparing them with a normal desktop computer screen resolution. If the 3D worlds for these sizes are developed, it will be necessary to consider a maximum depth for the scene and a maximum complexity of the elements. For example, if there is an element included in a world with a depth of 300 units and the element is positioned in the bottom of the world, this object will appear very small and

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Fig. 1. Desktop computer screen with 1280×1024 pixels resolution and four images overprinted: one little logo (200×71), one small photograph (300×225) and two screen captures show the typical resolution of Sun mobile phone emulators.

only the outline shape can be seen. The situation can be described more accurately with these data: the world will be 200 units in width, 200 units in height and 300 units in depth; the element will be a square of 50 units each side situated at the bottom of the world and the result will be a small square less than 25 pixels wide. If the possibilities presenting useful information using 25×25 pixels are considered, it will be realized that they are very limited. So, the information displayed must be reduced to only the most vital and the tools to be developed are those using less space but include more interaction with users and more demand on communication.

In this situation, the same dilemma is faced again; on the one hand we have the PDA option with no actual use in real scenarios and with better hardware capabilities. On the other hand, we have the mobile phones and the very restrictive conditions that will be useful if we achieve a good usability level in the interface to be accepted by the users. The clear choice is the mobile phone and our main objective is to achieve the usability. Thus, guidelines will be established to create 3D worlds big enough to contain the learning materials and small enough to fit the display. Guidelines validity will also be established.

We have been working with this goal in mind.

OBJECTIVES AND TESTING ENVIRONMENT

The main goal is to set the rules to create 3D Worlds which can be used successfully in a typical mobile phone. As discussed in the introduction, the opportunities of using 3D techniques over mobile phones are very good, and m-learning can take advantage using them to create better environments for learning [3] [4]. With these worlds we can offer on the screen all the information needed by the learner distributed in zones with different levels of detail depending on the 3D position of the zone. The zone being used at each moment, is the focus and is shown closer to the user and with better resolution.

Therefore, before the start of commercial competition for the market among companies, we need to establish the technical limitations and the recommendations to ensure the success of the applications. One significant case highlighting this situation, which can lead to the complete failure of a new technology, is WAP which was announced as 'Internet in your hand' [5]. This marketing definition tried to sell it to all mobile phone users but WAP has not reached desktop browser usability levels and for this reason has resulted in disenchantment and almost no applications.

It can be seen from our main objectives that it is necessary to establish the limitations of every component involved in the construction of the 3D worlds. Also, we have to set up the test that will consist of software tools and the selection of an acceptable range of screen sizes.

Testing environment

The most commendable software testing environment is the one released by Sun in its Wireless Development Kit. The reason for this preference is the fact that Sun created the language and, through the JSR Program [6], set up the extensions and modification to the platform. In this tool there are four emulators which represent four different types and sizes of phones. In Fig. 2 we show these emulators.

Fig. 2. Sun mobile phone emulators. From left to right we have MediaColorSkin (177×180), DefaultColorPhone (289×240) and QwertyDevice (204×540). Each emulator uses different screen sizes.

In the environment provided by Sun, the applications can be developed without the cost of using OTA (Over The Air) installation or without needing any hardware investment. The main problem appears after the development phase when we need to translate the programs to real phones for execution. Most of the time we need to make adjustments in the programs to fit them correctly in the screens where the resolution will differ, most probably, from the resolution of the emulator screen.

Reference measures for recommendations

As shown, the emulators have different sizes compared to real phones. For our purposes, it is necessary to have an approximation of these detailed sizes to obtain useful recommendations which can be applied to every phone that complies with minimum screen requirements. An exact output in terms of pixels is not important, but this exact output will only fit a single emulator or phone.

For these reasons we have chosen a resolution of 200×200 pixels for making the recommendations. Also, we assume that we can use 65.535 colours (2 Byte, 16 bits), which is the standard available in most of the phones. This screen size allows us to maintain easy mathematical operations and to obtain representative values for many of the current models of mobile phones.

Fig. 3. MediaColorSkin (177×180) and DefaultColorPhone emulators (289×240) running the application which shows the images previously overprinted on a desktop computer's screen.

As an example of the convenience of these sizes Fig. 3 shows the output of the execution of a simple application with the resolution of the screen and two images, one after the other. The images are the same as seen in the overprinted image of a desktop computer screen in Fig. 1.

STUDY OF DEPTH

Now there is a window to see the world inside the phone set up to 200×200 pixels and now is the time to put in the pieces to populate it. Following tests, the recommended size for components inside the world will be obtained. Finally, an example world will be created with useful limits expanded from the 2D version but restricted to fit the small screen of the phones. The key need to achieve success in this task is the depth.

The depth of the 3D world simulated in the phone will be the most important limit to set up in order to ensure that all the contents can be used effectively. The best situation possible includes a world without limitations but, the constraints of the display must be taken into account. One element far enough from the observer can only be represented using a single pixel which is not useful for any application. Without going so far, an object placed at 50.0 units from the observer will be represented half size (using normal camera parameters). If the position is changed to 50.0 units deeper, the object will be seen quarter size, and so on.

Another point which must be taken into account is the available memory in the devices. In the test carried out, it was observed that the number of objects cannot be very high or a Java Error message appears: java.lang.OutOfMemoryError. During the experiments this error appeared often so it was decided to reduce further the limits of the world.

Finally, we need to set up the depth of the world in 100.0 units, big enough to include many elements (much more than a 2D interface) and limited to ensure the supply of memory. Also, to simplify the task of creating a world that can be used in mobile learning activities another restric-

Fig. 4. DefaultColorPhone emulator running an application with one room inside.

tion must be established; the world will be organized in fragments with the shape of a cube called 'room'. Using these rooms, limits can be set up as needed, the depth feeling is achieved and the contents can be organized. Figure 4 shows an empty room with textures in walls, roof and floor.

Inside the rooms the desired information is inserted, using the volume created to organize the contents of the information currently in use. In a simplified form these rooms can be seen as a combination of five screens. The rooms can contain any 3D or 2D components needed to create the application, but not every element will fit to the same degree with the requirements of the situation.

Volumes

These elements are the most representative in 3D worlds; they can be used to represent any object in a very real and flexible way. In Fig. 5 we illustrate these possibilities through an example included in the emulators of Sun and a representation of a sphere of one of the tests created to move the camera and objects through the world.

However, these volumes enclose the greatest potential of 3D graphics, in this case, they are not the best option. As can be seen from the examples of Fig. 5, using volumes consumes too much space in the scene and the space must be limited to ensure the usability through the legibility of text or details of images.

For this reason, to create the 3D tools for m-learning, volumes will be neither used nor recommended for use, at this time. They can be used and recommended in a future development, with bigger screens and better resolutions.

Planes

These shapes only reach their maximum potential possibilities in 3D worlds. In a two-dimensional space, planes can be assimilated to polygons but in 3D the planes are the needed pieces to build every other shape, like volumes, or to draw a scene like the rooms used in this work.

Also, the planes will be the supporting media to insert images and to move these images through the world without limitations. Furthermore, planes do not consume spaces as they are flat.

For these reasons, planes will be the preferred tool to create the worlds using them to set up the rooms to add images in rooms or any place needed, to draw any shape or, even more, to substitute lines.

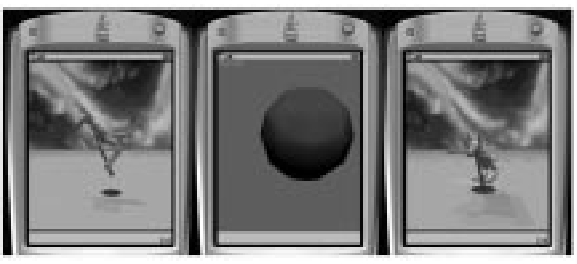

Fig. 5. Examples of 3D World and volumes in the DefaultColorPhone emulator.

Lines

This element is representative of 2D graphics and will not be used directly in 3D worlds. If it is used, we draw directly in the Graphics object of the Midlet and this causes lines to appear overprinted in the display. The result is the same as painting in a window; the lines are not seen correctly and the elements at the other side of the window cannot be well observed. This 'painting in a window' effect may be interesting for future applications in m-learning systems, like alerts or another use but, now it is not recommended as we want to establish the 'inside of the world' rules.

However, it can be integrated in the planes, using them to create an image which can be included as a component of a plane. This option is slightly complex; it requires the creation of an image on the fly in order to obtain from it a Graphics object. Then, it can be drawn on this object which will be shown in the scene. When this is done we use the image to fill a plane which will be shown on the screen.

This alternative allows creation of specific content to fill the planes—walls of the rooms, for example—but it must be used carefully due to the complexity of the operations. A demonstration of 2D lines and text are shown in Fig. 6

Text

This element is very important because it is the only one that can be used to communicate complex instructions to learners and specific data. Also, interaction using text cannot and must not be substituted absolutely by other graphical techniques. This is because the more expressive elements like graphics are more restrictive in the combination of possibilities supported.

For this reason the adaptation of text into the 3D interface, a complex task, is absolutely necessary.

Bitmaps, textures and backgrounds

The last element to consider for use in the construction of the worlds is the images which can receive names related to their use in the scene. The background requires studying a unique image situated at the bottom of the scene.

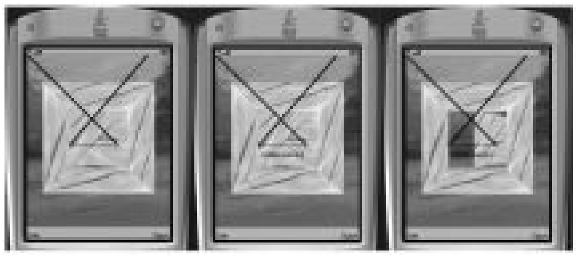

Fig. 6. Demonstration of 2D lines and text over a 3D world.

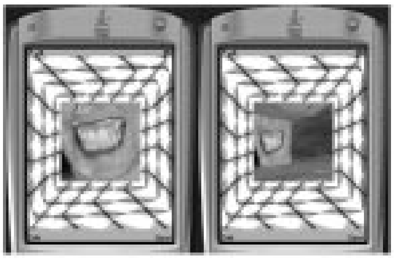

Fig. 7. Examples of a texture, an image and the background. The screen captures two moments in the execution. In the first the background is hidden, in the second the rear wall has been moved and the background appears.

Every other component is situated over the background and when no element occupies a place, the background can be seen through it. The second name for images is textures which denote images used to cover the surface of volumes or planes to give them a more realistic appearance. Finally, images used to cover planes with the objective of getting this image shown will be called only images or mapped images.

These images will be very useful helping to enrich the worlds with colours and figures easily. The only problem with these elements is the size they can reach. To avoid the problem, there are restrictions: only images with 32×32 pixels in compressed formats can be used. Figure 7 shows two moments in the execution of a program where the background, textures and images can be observed.

TEXT

It is necessary to write text, but there is the problem of making it compatible with the 3D worlds. Our solution is the creation of a library of letters and symbols composed with 3D planes. The written text using this library is almost a volume, more than a set of planes, and much more flexible and adaptable to 3D worlds.

Each letter can be manipulated as other shapes in the scene, translated and rotated. Also, a group of letters can be transformed into a group which allows the same operations without the necessity of repeating them and simplifying the global programming of the world.

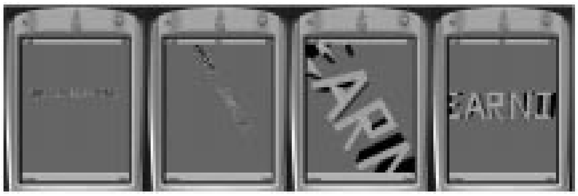

Fig. 8. Examples of 3D text generated using planes. The library created allows texts movements as shown in the images.

In Fig. 8 examples of the use of this library to write mobile learning are shown.

EXAMPLES AND REAL PHONE EXECUTION

As a result of the tests we create the mobile-learning worlds as a set of rooms applying the restrictions established for each element.

Figure 9 shows some of the last test runs and the execution on a real phone. This figure also includes some of the photographs of other previous examples and the execution of rooms creation in the phone.

CONCLUSION AND FURTHER WORK

The main conclusion is that 3D worlds can be very useful in the creation of mobile-learning applications. They allow the creation of environments where the users can retain on the small screen most of the information needed, and by changing the focus to a different zone will increase the detail level. The proposed measures can help establish the maximum amount of information and zones, and the minimum sizes of zones without focus.

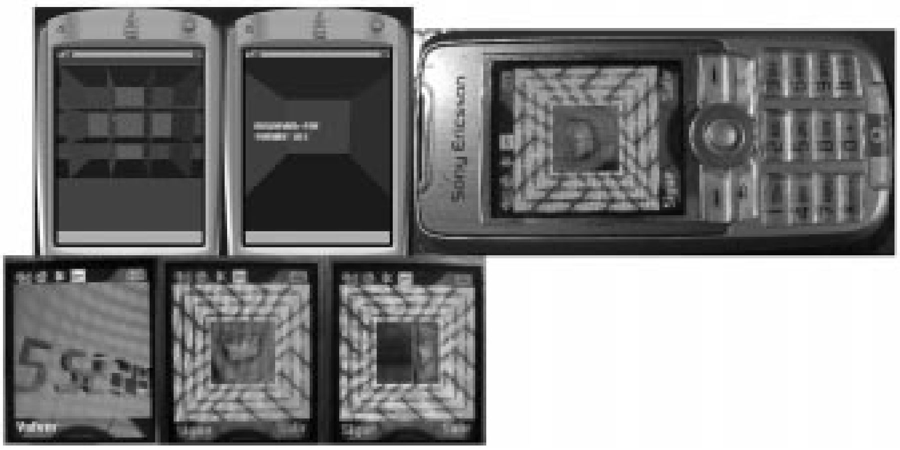

Fig. 9. Examples of 3D programs creating rooms and running in a real phone.

The second conclusion is that many problems or limitations will appear during the construction of the tools but the result obtained will justify the effort.

Also important is the need to develop a real tool or system using 3D techniques to test the limitations of the technology and the devices. These conclusions lead to the first objective of future work as the creation of a system which allows self-evaluation of exams through the mobile phone.

Finally, we set as a future task work adaptations to help handicapped people use these types of technologies.

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