PlayWithEyes: a new way to test children eyes Short Paper

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***Abstract*—One of the major problems of doctors when dealing with children is to capture and maintain their attention. This is particularly true for oculists that must test children eyes, especially if the are very young. In this paper we present *PlayWithEyes*, a serious game that aims at testing the children eyes while they are having fun playing with Lea symbols and images taken from popular cartoons, using a touch interface. *PlayWithEyes* was created to perform screening of visual acuity of very young children, since early diagnosis is very important for some sight defects like amblyopia (lazy eye).**

***Index Terms*—serious games; game-based diagnosis; assistive technologies; multimedia applications; mobile devices;**

I. Introduction

No doctor can perform a good diagnosis without the patient's collaboration. The problem is that doctors cannot always take for granted patients' cooperation, especially when dealing with children. One of the major problems, in this case, is to capture and maintain their attention: children cannot be considered like little adults. This is particularly true for oculists that have to test children eyes, asking them to look at some projected letters and to recognize their orientation. This task is so boring for children that sometimes, especially for very young children, their responses become wrong, or not accurate, since their are not longer interested in the task. There exists some eye diseases for which an early diagnosis is very important, *amblyopia*, commonly known as *lazy eye*, is one of them.

Amblyopia, is the eye condition denoted by reduced vision not correctable by glasses or contact lenses which is not due to any eye disease. The brain, for some reason, does not fully acknowledge the images seen by the amblyopic eye. It is estimated that three percent of children under six have some form of amblyopia. Moreover, amblyopia causes more visual loss in the under 40 group than all the injuries and diseases combined in this age group [1]. One of the major problems of this eye disease is its diagnosis, since the patient usually does not understand to have a visual disease since he/she is not aware that he/she is using only one eye.

Treatment for amblyopia begins as soon after diagnosis as possible and an early treatment usually can reverse the condition. Treatment is best started before age 6 and should begin before child's vision has fully developed, which is around age 9 or 10, after amblyopia can be hard to correct. The younger the child is when treatment begins, the better his or her chances for having good vision are. Some studies [2], [3] have shown that better results can be reached with earlier diagnosis.

Children who received orthoptic screening for amblyopia between the ages of 8 and 37 months have better outcomes from their treatment at 7.5 years than children who are screened only at 37 months. Williams et al [2] randomised 3490 children to receive either intensive or once only orthoptic screening. They found that those children given intensive screening had a lower prevalence of amblyopia and better visual acuity in the worse seeing eye, supporting the hypothesis that early treatment leads to better outcomes.

For this reason it is very important to allow orthoptic screening for very young children.

In this paper we present *PlayWithEyes*, an application which aims at testing children eyes through the use of a game. We ask to preschool children to perform a Lea vision acuity test [4] by recognizing symbols projected on a wall and pointing them in a touch interface, i.e., an Apple iPod Touch, which displays the Lea symbols. In order to obtain their collaboration, we use the *serious game paradigm*, so that children can have fun playing a game without understanding that they are testing their eyes. Children are engaged and encouraged with audio message, e.g., an applause in case of correct answer. Images taken from popular cartoons are projected together with Lea symbols.

The children can choose and touch a symbol on the interface or change the orientation of the device to match the orientation of the symbol. This possibility provides a very friendly interaction, even for younger patients. Moreover, the use of the serious game paradigm helps to improve the diagnosis of very young children, because the eye test may last longer since they have fun, allowing the doctor to better observe the little patient.

PlayWithEyes allows to test not only visual acuity but also color blindness.

II. Related Works

The *"serious game"* paradigm aims to engage users into an activity, usually that produces a common good, concealing it into a game designed for a primary purpose other than pure entertainment [5]. The idea is that the user does something useful, which normally would not, because he/she enjoys doing it. Serious games can be used to develop new knowledge or skills. An example is Google Image Labeler [6], a game that challenges two users to find a common keyword to tag an image, i. e., a clever way for Google to ensure that its keywords are matched to correct images. This operation is not possible without human intervention.

Recently the serious game paradigm begins to be used in health care. In [7], Kato explores the positive aspects of using existing commercial video games for health improvements or surgical training, and tailor-made game for particular disease group in order to improve recovery and rehabilitation of patients.

Since our system is specifically intended for preschool children, we must pay particular attention to the interface. Many papers address the problem of interface for children. Among others, [8] describes a game which allows preschool children to access information. Children use magic objects to query and navigate an image database. Forlines et al [9] investigate the differences between mouse and direct touch input, both in terms of quantitative performance and subjective preference. They conclude that touch interfaces, even if they may not lead to greater performance, especially for speed and accuracy, are preferable for other considerations like fatigue, spatial memory and simplicity.

A. Existing Software

A certain number of software products that provide vision tests exist, both for professional and personal use. At the state of the art the main professional solutions that can be adopted by ophthalmologists are listen below:

- 20/20 Vision (Canela Software) [10]
- PVVAT™ (Precision Vision) [11]

Both products are desktop applications for professional use. The software shows the tools used by oculists (eye charts, Snellen tables, etc.) on the desired screen to test patients. The screen can be either a computer monitor or an external display. Both products do not focus on testing children patients specifically, even though Lea optotypes can be used. Moreover, these solutions do not use a game paradigm to improve users' attention.

Given the proliferation of mobile phones, another set of interesting software solutions are applications that allow users to self test their visual acuity with a cell phone or a portable device. The relevant applications are:

- Acuity (Intellicore)
- EyeChart HD (Dok LLC)
- Vistion Test (3 sides cube)
- FastAcuity Lite (KyberVision Consulting, RD)
- Vision (AppZap)
- Eyetest (Konrad Feiler)

All the listed applications for iPhone, iPod Touch or iPad, behave almost in the same way with non perceptible differences. They propose daltonism tests based on Snellen tables and acuity tests based on eye charts and Landolt rings. Applications like these, often developed with no strong specifications, provide nothing more than simple self-made tests with no real implications. None of these applications considers children specific requirements or makes use of a game to test eye, therefore they do not solve the problem to maintain children attention.

III. Description of the game "PlayWithEyes"

PlayWithEyes is a serious game which can be used both in kinder gardens and doctor's surgeries with different implications. In the first case, the game uses a set of preconfigured tests, studied by a group of oculists, so the teacher can easily test children simply by inserting children names. Children can be inserted in the database and classroom can be created before the test, in order to lower the waiting time between a child and the next one. This is particular important because we do not want the children get impatient while waiting. Each child is tested individually and the report, obtained while playing, indicates if the child need a specific visual examination by an oculist.

If used by a doctor, our system is just a facility for the oculist to obtain a better cooperation from the children, because as long as they have fun, they continue playing, thus testing their visual acuity. This helps to obtain a more precise sight examination, since the eye test may last longer, thus improving the possibility to perform a correct diagnosis for very young children.

Visual acuity is tested through standard Lea tests [4]. Lea symbols are specifically defined for preschool children because of their simplicity: children are able to refer to them without ambiguity even if they cannot read letters. The original[1] symbols are four: a house, an apple, a square and a circle. Images taken from popular cartoons are used to maintain the children concentration on Lea symbols. For example, the game shows in sequence apples and circles. The child must recognize the symbol and put the apples on a basket in the hands of Winnie The Pooh, and the circle in a basketball basket. To improve entertainment, some non misleading animations are shown on the wall.

A very simple interaction paradigm is provided: children give their answer by touching the right symbol on the device, or changing the device's orientation in order to match the orientation of the symbol.

Daltonism tests show cartoon characters with parts of the body colored differently from each other in order to test the children ability to recognize the right color. The child must choose the correct color on a palette depicted on his/her device and touch it.

The serious game on *iPodVision* uses accelerometer feature, animations and sounds, e. g., an applause in case of correct answer, to enhance the game experience. The game is intentionally left skinny to avoid any kind of negative interferences with the examination during the game play. Additional kinds of exercise will be implemented according to specific ophthalmology advices.

[1] Some minor variants with additional optotypes are also used in ophthalmology.

IV. System Architecture and Development

Before presenting the architecture, some considerations on the chosen devices are discussed. The actors involved in the usage of the product are kinder garden teachers, oculists and children. None of them are supposed to have any special knowledge about the use of computers, therefore an important target to achieve is to provide a simple and easy-to-use product with a friendly interface for final users.

To this end, some aspects play a significant role, like the preference of easy-to-use devices with minimal configurations, the rising market of smart phones and tablets and the preference of interaction with touch interfaces among traditional ones. The first aspect is desirable in order to avoid problems during the use of *PlayWithEyes*; the third one is much more important since we have to deal with non-expert users and with children that do not understand non trivial input interfaces. According to discussion in Section II, we choose a touch interface, since we think it is best suited for children, that are naturally inclined to interact with the outside world through touch. For this reason, we use an Apple® iPad for the device in use by the teacher and at least one iPod Touch or iPhone for the device given to the children. Moreover, a projector is also needed to execute the vision screening tests.

PlayWithEyes has a classic server-client behavior, based on the following components:

Server: used by the teacher to configure the vision tests. The server runs on an iPad. We call this component "*iPadVision*".

Client: used by the children to play the game, i. e., to perform the preconfigured tests. The client may be execute on an iPod Touch or an iPhone. We call this component "*iPodVision*".

Both server and client make use of the typical gesture of touch and tablet devices. Using an iPad as a server is not a common choice, but it represents the best solution in our scenario. In fact, the server is used both to project the eye test on a wall, and to interact with the doctor or teacher to select tests or create new ones (in the case of doctor), or to input children data (name, surname, age, etc.). Given the choice to use a touch interface in order to keep the interaction easy and simple, the next goal to reach was to minimize the needed hardware components. For this reason, the entire server resides on the iPad, therefore its development has taken into account efficiency issues since it should be used in a scenario of low resources in term of CPU, network bandwidth and disk space. Figure 1 shows the system architecture.

It could be noticed that an iPad is not usually present in doctors surgeries or in kinder gardens, while the presence of a personal computer is certainly more likely, especially in kinder gardens. Even if market analysis ([12]) have shown that the market share for smartphones and tablets increased over the last year, so these devices are rapidly becoming common available, to support also this situation, we implement also a web application running on a traditional computer as alternative to the *iPadVision* which can be used when the cost of an iPad is not affordable. In this case of the usability of the tool degrades a little, but not its accessibility, since the eye tests can still be performed.

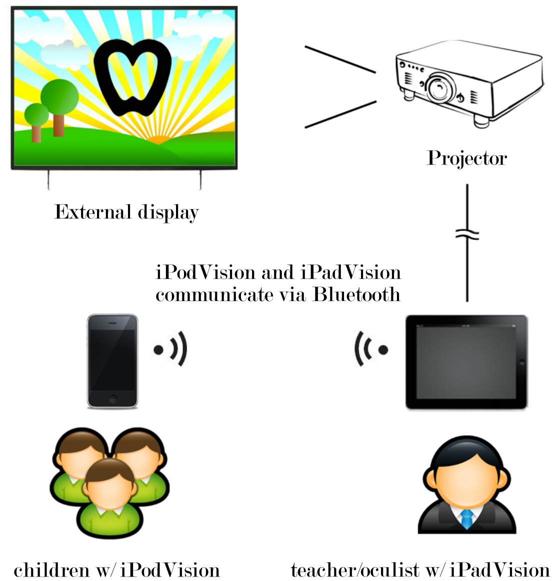

Fig. 1. Main System Architecture of *PlayWithEyes*

Given the described architecture, the following requirements were reached:

1) *iPadVision* must manage users and tests;
2) *iPadVision* and *iPodVision* must adopt the Bluetooth® wireless protocol to communicate with each other;
3) *iPadVision* must connect to a projector and manage what to display on the external screen;
4) *iPodVision* is the interface of the serious games for kids that must be easy-to-use and funny.

The first requirement allows to create and edit users, classroom and tests, but it is also necessary to keep track of the screening results in order to transmit data to oculist for diagnosis, in the case of screening in a kinder garden, and to permit statistic analysis. The Bluetooth protocol (requirement #2) allows the system to work even in absence of a wireless network: once more, we minimize the system requirements in term of hardware components. Moreover, the development of the system has shown that Apple devices allow Bluetooth communications in a very simple way.

During eye test, children have to respond interacting with the *iPodVision*, in accordance to what they are able to see projected on a wall at a given distance. The distance may vary between different executions of tests in different places, depending on the dimensions of the projected image on the wall and the projector settings. The system must help the teacher to configure itself, asking the teacher the distance from the wall and the projector settings and automatically projecting the tests in the correct size.

A. Technology details

The entire project relies on Apple products, therefore the software has being developed on iOS operating system. This choice has been made after considering many factors. At the beginning, we tried to abstract from the actual platform using a framework which allows us to develop an application using web technologies (HTML, CSS, Javascript, etc.), and to translate it into device native language (Objective-C for Apple or Java for Android). Titanium framework [13] has been tested with a basic prototype, but the experience made has shown that this framework is not mature and it's not suitable for our purpose, since Bluetooth connectivity and display on external screen are not supported yet. Moreover, the same problem affects also Android devices, for which a standard way to manage external screens does not exist. For this reasons, using the Apple SDK for developing the software appeared to be the right way to go through, and *PlayWithEyes* completely relies on Apple products.

Recent versions of the Cocoa framework adopted by Apple expose an API that fulfills the previously listed requirements. The communication is supplied by the *GameKit* framework, whose main focus is to wrap the well-known *Bonjour* implementation of the *Zeroconf* protocol in order to establish a communication channel between two devices without asking users any configuration parameters. The *UIScreen* class provided by Cocoa in the *UIKit* framework enables the possibility to handle an external screen and to decide what to display on it.

V. Conclusion

In this paper we have presented *PlayWithEyes*, a serious game designed to allow eyes test for very young children. *PlayWithEyes* can be used for screening children in kinder gardens, aged from 3 to 6 years old, but it can be used also in doctor's surgeries with younger children. The use of the serious game paradigm helps to obtain their cooperation because they have fun, so the eye test may lasts longer, thus improving the possibility to perform a correct diagnosis: this is particular important for some sight defects like amblyopia.

PlayWithEyes was provide a touch interface both for children and teachers/doctors since the use of this technology improves the accessibility and usability of interfaces for very young, not expert, users. At the time of writing, only a little tests set has been done successfully, but our system will be deeply tested in three kinder gardens by about 200 children and 18 teachers in May, 2011. Moreover, the gameplay of the system is currently under evaluation of a group of expert in children care and ophthalmology.

Future works will be devoted to include new type of tests, i. e., new games, to improve the users interface and to better investigate the adaptivity of the system to the set of available resources (e. g., in the case of the server which runs as a web application).

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