Gaze tracking, attention and interactive applications

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Abstract

Applications that use eye and gaze have recently become increasingly popular in the domain of human-computer interfaces. In this paper we address the use of gaze tracking in order to adapt entertainment and edutainment applications according to user behaviour, and more precisely his attention. We developed a framework dedicated to the analysis of attention (region of interest and model of inattention) and we have implemented it in a general agent-based architecture. The first application that uses such an interactive system is the AutiSTIC project. Our main objective is to implement a system that can help autistic children during the rehabilitation process. It consists in helping the child to be focused on his task during a computer game or exercise. The main goal of the activity is to help the child to improve his understanding about himself and his environment. The experimental results verify the feasibility and validity of this interactive system and the effects on the attention of children.

Chapter 1

Introduction

In humans, gaze direction and ocular behaviour is probably one of the first *distant means of communication* developed. Parents often try to understand what their baby looks at, and they deduce that the object observed attracts his/her interest. This ability to interact with someone by a transitional object is named *joint attention*.

Kaplan says that among the fundamental prerequisites for the development of complex linguistic skills, the development of joint attention is probably one of the hardest problems to be solved [8]. The biological significance of ocular behaviour and gaze direction in humans could be illustrated by two main facts. The first one is that in primates and more precisely in humans the visual cortex is more developed than in other mammals.[1]The second one, is that humans (and not primates), have clearly visible white area (sclera) around the pigment part of the eye (iris) (cf. Figure 1.1).

It is well established that eye contact is one of the first behaviours developed

[1]The visual cortex is located in the posterior pole of the occipital cortex (the occipital cortex is responsible for processing visual stimuli). It has been proved that the visual cortex is highly specialized in the processing information about static and moving objects and is excellent in pattern recognition.

Figure 1.1: The visible white area of human eye (sclera) makes it easier to interpret the gaze direction.

by young babies. Within the first few days of life, they are able to focus their attention on their mothers' eyes (especially when baby is held at the breast level). Eye contact and gaze direction continue to play a crucial role in social communication throughout life. Among the communication tasks in which eye direction is important we can mention:

- emotions;
- dominance or submissiveness;
- attention or disinterest;
- ...

In this work, we are mainly interested in the relation between gaze tracking and attention, which is the cognitive process of selectively concentrating on one thing while ignoring other things. After presenting the specific point that we have decided to tackle, we present our observation system in section 2 and how it collects information. Section 2.2 deals with the concept of attention and propose two models to determine when people has to be considered as inattentive. Section 2.5 presents the general architecture that implements our models of attention and which control interactions. In section 3, the AutiSTIC project is presented. Our main objective is to implement a system that can help autistic children during the rehabilitation process. It consists in helping the child to be focused on his task during a computer game or exercise. The main goal is to help the child to improve his understanding about himself and his environment. The experimental results verify the feasibility and validity of this interactive system and the effects on the attention of children.

Chapter 2

Gaze tracking, attention and interactive applications

Even if many researches have addressed the use of gaze tracking in games, to our knowledge none have specifically used gaze tracking in order to adapt entertainment and edutainment home personal applications. To fill this gap, we developed a framework dedicated to the extraction and analysis of low level visual features. First, we present the observation system, then we deeply explain what interest us in the behaviour observed. We also describe the models we have implemented to characterize them. Finally we briefly present an agent based architecture which allows applications to adapt their profile depending on the player past and current behaviour.

2.1 Context and observation system

From the hypothesis previously presented some material constraints have emerged:

- non invasive material;
- low cost;
- single user;
- recordable information;
- standard computer.

For our first experiments, we have decided to use *FaceLab*, it is a robust and flexible contactless vision-based system for tracking and acquiring human

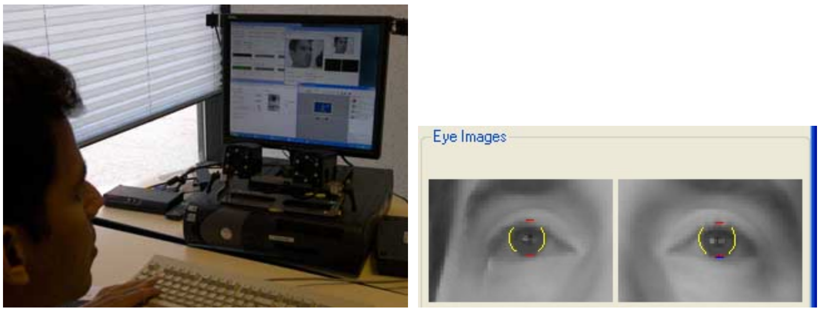

Figure 2.1: A non intrusive eye tracking system.

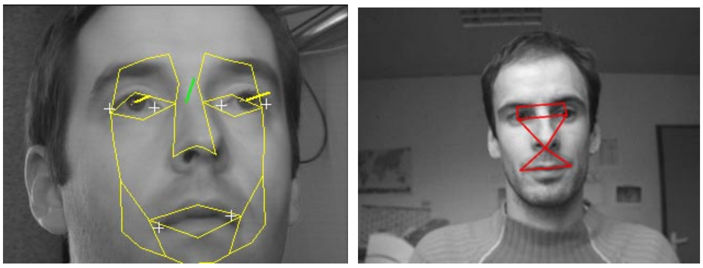

Figure 2.2: Using of a head model to detect eye and gaze orientation.

facial features (see Figure 2.1). Nevertheless it is a costly equipment, as a consequence we have decided to build our own low cost eye tracking system, keeping *FaceLab* as a *gold standard*.

Our system is based on a low cost grayscale ieee-1394 camera connected to a standard computer. Despite its low cost, this camera captures video frames of size 640x480 at 30 frames per second which are suitable characteristics for both accurate face features localization and efficient face features tracking (no efficient tracking prediction can be done under 10-15 fps as at this frame rate, eyes and face movement become chaotics). The choice of a grayscale camera instead of a more common colour camera is driven by the fact that most of the aimed applications are performed in an indoor environment. In such an environment, the amount of light available is often quite low, as grayscale camera usually have more sensitivity and have a better image quality (as they don't use bayer filters), they are the best choice. Another advantage of grayscale camera is that they can be used with infrared light and optics that don't have infra-red coating in order to improve the tracking performance by the use of a more frontal and uniform lightning. Although we don't use this possibility yet, it could be a further improvement.

The tracking algorithm we have developed is built upon three modules which interoperate together in order to provide a fast and robust eyes and face tracking system (see Figure 2.3).

- *The face detection module* is responsible for checking whether a face is present or not in front of the camera. In the case a face is present, it must also give a raw estimate of the face and face features (eyebrows, eyes, nostrils and mouth) 2D position in the image. As we are working with grayscale image we cannot use skin colour detection to locate the face area. Instead, this module uses a Hough derived algorithm specifically developed in order to locate circular shapes that lie within a predefined radius range. This radial symmetry detection algorithm is run twice : a first time to locate circular region of radius in the range 10-60 pixels (on a scaled down 160x120 image of the original 640x480 video frame) in order to find an approximate face region candidate; and a second time in order to find circular shaped region of radius lower than 8 pixels representing the eyes. These two steps result in a candidate face region which is then checked for a face using a 2D face model (see right image of Figure 2.2).

- *The face features localization module* finds the exact features position with a sub-pixel accuracy. It is based on [17] algorithms. When all features position is known we use the method described in [7] to estimate the 3D position and orientation of the face and eyes.

- *The features position prediction module* processes the position of each feature for the next frame. This estimate is built using Kalman filtering on the 3D positions of each feature. The estimated 3D positions are then back projected to the 2D camera plane in order to predict the pixel positions of all the features. These 2D positions are then sent to the *The face features localization module* to help it process the next frame.

An important property of our tracking algorithm is the cascade of information generated (see Figure 2.3). The algorithm tries to give as much information as it can with the best accuracy. But if it fails to locate some features, it still delivers some low level information. For example, if the algorithm doesn't manage to find the eyes of the user, it will still deliver the face position and a raw estimate of the eyes position since it is processed in the *face detection module.*

For the moment, no calibration is required by the system. We have made this choice because the accuracy needed by the applications using the system

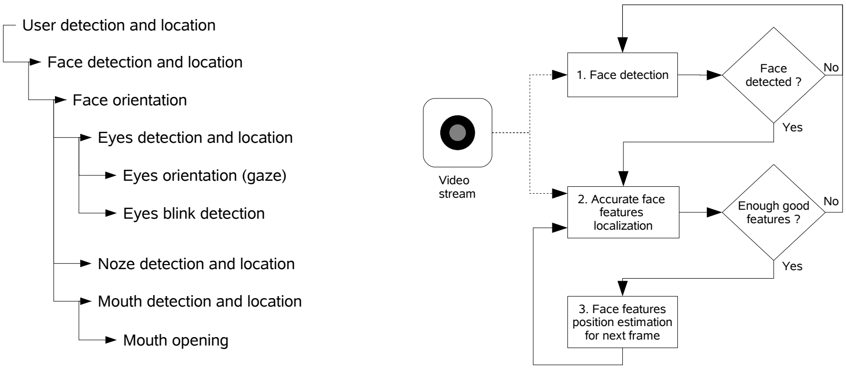

Figure 2.3: Left: The cascade of information generated by the tracking system. Right: General architecture of the face and eye/gaze tracking algorithm.

(mostly educational games for children with autism) is quite low (in the order of the quarter of a screen). Furthermore, skipping the calibration step result in much easier to use applications (especially for children with autism).

The next section deals with attention and its relation with eye and gaze behaviour. We mainly use psychology and cognitive neuroscience classification [1]. Once *interesting attention* defined, we present our work relating to the integration of such input into an interactive application. We present the architecture of our software and the methodology we use to analyse some particular behaviour.

2.2 Attention

Classically, attention is historically defined as follows [6]:

> Everyone knows what attention is. It is the taking possession by the mind in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought...It implies withdrawal from some things in order to deal effectively with others.

Thus, attention is the cognitive process of selectively concentrating on one thing while ignoring other things. In spite of this single definition, it exists several types of attention:

- Awakening: becoming awake is a metabolic state which is characterized by consciousness, the opposite of sleep, in this state, we are sensory open to the world.

- Selective attention: A type of attention which involves focusing on a specific aspect of a scene while ignoring other aspects. Selective attention can be conscious (as when one chooses to attend to an interesting object instead of a less interesting one) or unconscious. An interesting point which characterizes children with autism is that they are unable to choose which event is more or less important. As a consequence they are often *saturated* because of too many stimuli and thus they adopt an extremely repetitive, unusual, self-injurious, or aggressive behaviour.
- Maintained attention: this kind of attention appears after the previous one. It is the *activity keeper*, allowing focusing and avoiding distraction.
- Shared attention: skill to treat two or more different types of information (sound, motion, action...)
- Internal or external absent-mindedness : internal or external preoccupation so great that the ordinary demands on attention are ignored.
- Vigilance is the act of watching for something to happen, of watching for danger. It is not something that humans are very good at, since it is difficult to maintain attention for a very long time without some stimuli.

For an interactive task, we are mainly interested in *selective and maintained attention*. The analysis of the first one allows to know whether people are involved in the activity. The second one enables us to assess the success of the application.
The best attention markers we can measure is undoubtedly eye and gaze behaviour. A major indicator concerning another type of attention, *vigilance*, named PERCLOS [3] is also using such markers; so do *awakening* [10]. In continuity of such studies, we based our markers on eye and gaze behaviour to determine selective and maintained attention. A weak hypothesis is that a person involved in an interesting task focuses his/her eyes on the salient aspect of the application (screen, avatar, car, enemy, text...) and directs his/her face to the output device of the interactive application (screen). As a consequence, eye and gaze tracking could be an efficient estimator of attention. Nevertheless, if a person does not watch a screen, it does not necessarily mean that he/she is inattentive, he/she can be speaking with someone else about the content of the screen [8], or he/she can watch the screen but be dreaming at the same time. In order to treat these different aspects, we have decided to adopt the following solutions:

- if the user does not watch the screen during a time t, we conclude to inattention. In the following subsection, we present how t is determine.

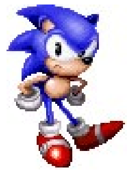

Figure 2.4: Sonic indicates its boredom by stamping one's feet after a time statically defined.

- in order to determine if the user *dream* in front the screen we correlate gaze and salient parts of the screen.

In both cases, if inattention is detected, we inform the application.

2.3 A simple model of human *inattention*

This part concerns persons who do not watch at the application output device. The goal of this model is to define the delay after which the application will try to refocus the user on the activity. Actually, we easily understand that in this case, an interactive application does not have to *react* the same way if people play chess, role player game or a car race. Until now, this aspect of the game was only directed by the time during which nothing was done on the paddle or the keyboard (Figure 2.4). We based our model of what could be named *inattention* on two parameters:

1. the type of application;
2. the time spent using the application.

The last parameter depends itself on two factors:

1. a natural tiredness after a long time
2. a disinterest more frequent during the very first moments spent using the application than once attention is focused, this time corresponds to the delay of *immersion*.

Once the parameters are defined, we propose the following model in order to define the time after which the application try to refocus the player who does not look at the screen.

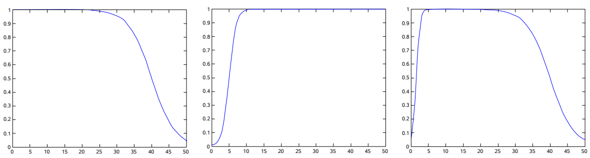

Figure 2.5: Left: modelisation of tiredness evolution. Middle: Modelisation of interest probability. Right: Model of potential of attention. Abscissa represents time in minutes. Each curves is designed for a single person involved in an unique activity. ($\alpha_1 = 1$, $\alpha_2 = 3$, $\beta_1 = 0.3$, $\beta_2 = 12$)

2.3.1 Potential of attention

As we mentioned, potential of attention depends mainly on two parameters, tiredness and involvement. We have decided to model tiredness, or potential of attention, by a sigmoid curve parametrized by a couple of real number β_1 and β_2. β_2 represents the way tiredness appears, β_2 represents the delay after which the first signs of fatigue will appear and β_1 is correlated to the speed of apparition of tiredness (Figure 2.5).

$$P_{tiredness} = \frac{\exp^{-\beta_1 t + \beta_2}}{1 + \exp^{-\beta_1 t + \beta_2}}, \tag{2.1}$$

where β_1 and β_2 are two real parameters.

For the second parameter, we have once again modelled involvement, or interest probability, by a sigmoid. We started from the fact that activity is *a priori* fairly interesting, but if the person is involved after a certain time ruled by α_2, we can consider that interest is appearing at a speed correlated to α_1 (Figure 2.5).

$$P_{interest} = \frac{1}{1 + \exp^{-\alpha_1 t + \alpha_2}}. \tag{2.2}$$

For our global model of potential of attention, we couple both previous models and we obtain :

$$P_{attention} = P_{interest} * P_{tiredness}, \tag{2.3}$$

We have to note that this model was defined and validated on three children with autism and is still not validated on *ordinary* persons, nevertheless, the first tests are quite promising.

2.3.2 Delay of inattention

Once this model is defined, we are able to determine the time after which the software has to react (if the person still does not look at the screen). Here,

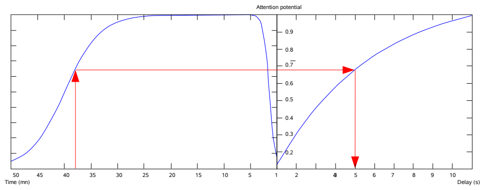

Figure 2.6: Curves used to determine the delay of software interaction.

it is an arbitrary threshold γ guided by experience, which characterizes each application. The more the application requires attention, the higher this coefficient is. The model we have adopted is an exponential function.

$$D_{game} = exp^{\gamma(t) * P_{attention}}, \tag{2.4}$$

γ is a function of time because we have estimated that it can exist several *tempo* in an application (intensive, stress, reflection, action ...). As a conclusion, we can summarize our model of inattention by the two following steps (Figure 2.6):

- depending the time elapsed from the beginning of the application, we estimate the potential of attention $P_{attention}(t)$;
- depending this potential and the application, we estimate the delay $D_{\gamma(t)}(P_{attention}(t))$ after which the software has to refocus the inattentive player.

This model is currently implemented in an application dedicated to children with autism (see section 3).

2.4 A model of ***absent minded*** behaviour

After dealing with people who do not watch at screen, we would like to emphasize on another behaviour, the absent minded person, the dreamer. A Person who looks at the screen but does not see what is happening. It is a quite common problem with children involved in an educative application (more uncommon with games). In this case, we have solved this problem using correlation between the salient parts of the image and eye and gaze tracking, actually it seems natural that gaze must *follow* what is happening on the screen. Half part of the work is done by the eye tracker, but how can we know what the gaze should follow ? We made the hypothesis that if the gaze moves inside the screen, everything is normal, but as soon as the

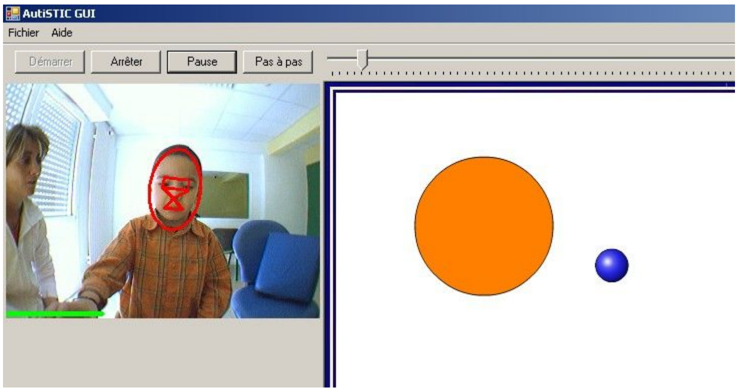

Figure 2.7: Real time regional motion computation and correlation with projected objects.

gaze fixes one point, we evaluate the application behaviour thanks to either software itself (if we master the game unfolding) or using real time regional motion estimation (Figure 2.7).
In the next section, we present the general architecture of our system in which our model of attention is implemented.

2.5 Interactivity and agent based architecture

As we already mentioned, our objective is to implement a system that could interact intelligently with a person when using an application. It consists in establishing a multimode and multimedia dialogue between the assisted person and the system. The architecture we have proposed aims to bring flexibility and modularity in the individualized rehabilitation of children with autism. Accordingly, we propose a system architecture which allows:

- to build a protocol, that satisfies the goals that everyone wants/must reach by taking into account his/her profile.;
- to observe the childs actions during the session in order to understand his behaviour;
- to detect cases where suggested activities are not answering to standard gait and to updates the protocol.

Figure 2.8 gives the general architecture of the system. To reach our objectives, our framework must be flexible in order to fit with child character-

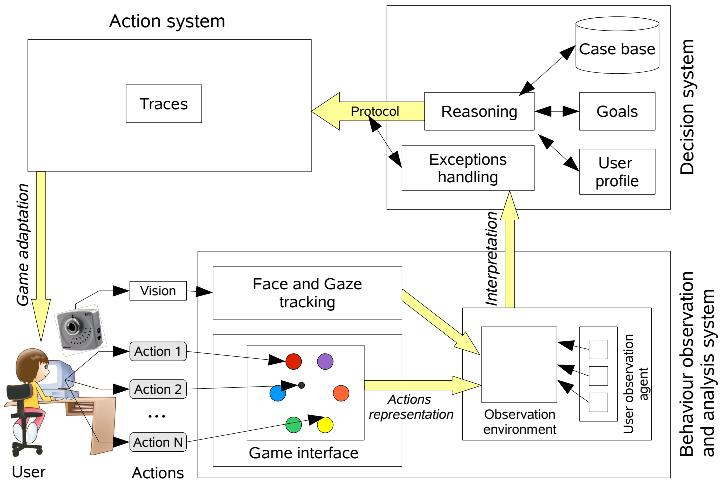

Figure 2.8: General architecture.

istics. Interested readers may found information concerning the agent-based system, *i.e.* the decision centrer, in [15] or [16]. We have listed three systems:

- system of observation and analysis of behaviour;
- decision system;
- action system.

The first one ensures the process of observation which consists in observing, analysing and interpreting the behaviour of the child. The second one consists in adapting and checking the execution of games and the last one consists in running games. The conception of the platform, represented Figure 3.1, was guided by the following constraints :

- it must allow to assess child competences, profile, behaviour;
- it must track eye and gaze behaviour, determined as the best markers of attention;
- it must allow to focus child attention and be able to refocus it if necessary;
- it must not perturb the child by inopportune interaction.

2.6 Conclusion

In this section, we have presented two models of attention which enable interaction guide by eye and gaze tracking. The first one is used when people do not look at the application, whereas the second one is used when people do not have a relevant gaze behaviour. These models have been implemented and validated with children with autism involved in an application developed to increase their capacity of attention. We are currently working on ordinary people to adapt the parameters regarding to recorded profile and potential evolution, as instance, the time after which people is involved in application is longer like the delay of tiredness. We have also presented a general architecture which reacts in a dynamic way thanks to the observation and analysis of behaviour. The principle of the architecture lies on the optimization of the extraction of information according to the context. In the next section, we present the AutiSTIC project, on which are based our tests.

Chapter 3

An interactive application for children with autism.

3.1 Introduction

The project that we carry out, called *AutiSTIC Project*, is a partnership with the *psychiatric service for children with autism* of La Rochelle hospital. Our objective is to implement a system that can help autistic children during the rehabilitation process. It consists in establishing a multimode and multimedia dialogue between the assisted child and the system and helps him to be focused on his task during a computer game or exercise. The main goal is to help the child to improve his understanding about himself and his environment.

3.2 Autism

Autism is not a disease, but a developmental disorder of the brain function. People with classical autism show three types of symptoms [2] :

- impaired social interaction,
- problems with verbal and non-verbal communication and imagination,
- and unusual or severely limited activities and interests.

Symptoms usually appear during the first three years of childhood and continue throughout life, since autism can't be cured. People with autism have a normal life expectancy. The hallmark feature of autism is impaired social interaction. Children with autism often have difficulties in interpreting the tone of voice or facial expressions and do not respond to other's emotions. Many children with autism engage in repetitive movements or in self-injurious behaviour. People with autism often have abnormal responses to sounds, touch, or other sensory stimulation. They also may be extraordinarily sensitive to other sensations. These unusual sensitivities may contribute to behavioural symptoms such as resistance to being cuddled.

Appropriate management may favor relatively normal development and reduce undesirable behaviours, even if autism degree presents a great deal in severity. This behaviour may persist over time, thus it is very difficult to live with people with autism, to treat[1] and teach them. The most severe cases are marked by extremely repetitive, unusual, self-injurious, and aggressive behaviour. Other forms of autism include a personality disorder associated with a perceived learning disability.

Among the different methods that have been developed to treat children with autism, we can cite: [14] :

- Psychological and behavioural treatment helps autistic children to approach the notion of *the other*, enabling them to build and re-use specific mental constructions to control their surrounding [9].
- the TEACCH method (*Treatment and Education of Autistic and Related Communication-handicapped Children*). TEACCH is not a single approach and even less a method [11]. It is a state program that tries to respond to the needs of autistic people using the best available approaches and methods known so far for educating them and to provide the maximum level of autonomy that they can achieve.
- *Facilitated communication* is an alternative mean of expression for people who cannot speak, or whose speech is highly limited, and who cannot point reliably. The method has been used as a mean to communicate for individuals with severe disabilities, including persons with labels of mental retardation or of course autism [12].

In this last item, we find scientific works supporting the idea that computer science can be used in the field of autism treatment. For example, Gepner [5] deals with the difficulty for children with autism to perceive rapid motion and Fabri [4] deals with the use of emotionally expressive avatars in emotions encoding, etc. As a consequence, computer science becomes a research area in the structuration of people with autism.

[1] We have to take care of the meaning of treatment, we means special education, adaptative care in order to give support to child and reduce consequence for family and people around him.

3.3 The *monotropism* hypothesis

A very interesting hypothesis that we will reuse later is the *monotropism* hypothesis [13]. It refers to multiple divided attention in the brain, the hypothesis is based on the fact that at any one moment the amount of attention available to a conscious individual is limited. In order to build efficient interactive applications for children with autism, we need to understand more deeply the cognitive explanations of autism. According to [13], autism is a weakness of the central coherence. This means that people with autism are poor at integrating material and can only be efficient when focusing on a single task. This is called *monotropism*. Authors explain :

> It is generally accepted that focus is a quality of attention. However, this optical metaphor may be extended to parametrize focus of attention between diffused light at one extreme and a torch beam at the other. That is to say, attention may be broadly distributed over many interests (the *polytropic* tendency) or may be concentrated in a few interests (*monotropism*).

As a consequence of their monotropic way of thinking, children with autism tend to perform tasks the better they can, but these tasks are not necessarily those psychotherapists wants them to do, that's the main reason why the application have to know when to interact with the child to refocus his/her attention onto a specific work.

3.4 The AutiSTIC project

As we already mentioned, the *AutiSTIC Project* tends towards implementing a system that can help autistic children during the rehabilitation process. The role of such a system is to provide the child with the personalized activities in the form of educational games. During a session, the system collects through various devices (camera, touch screen, mouse, keyboard) actions and attention, in order to understand her/his behaviour and response to it, in real time, by adequate actions considering directives. These directives concern rupture, avoidance, stereotype gestures... For instance, the system may attract attention by displaying an image on the screen, or by launching a characteristic music. It is impossible to generalize activities or reaction without precaution, we have to favour the adaptability of a system to take into account the specificity of person.It is important to locate and interpret carefully these *intrinsic behaviours* as eye and gaze orientation, in order to help him/her to rehabilitate. We do not have to perturb the child when he/she

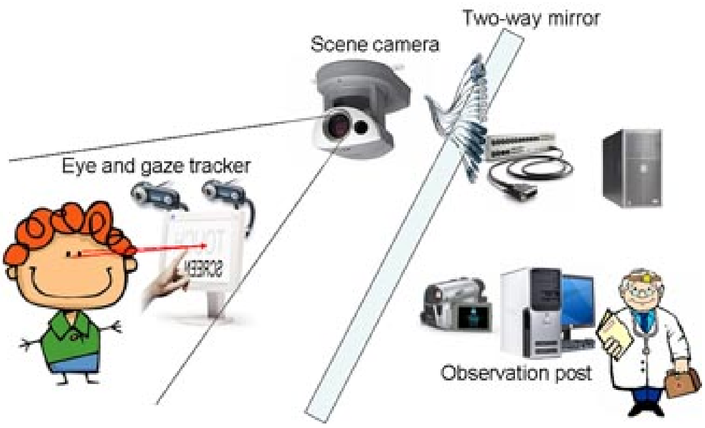

Figure 3.1: The AutiSTIC platform installed in the psychiatric service for children with autism. Work station of children and acquisition system.

is working, misinterpreting his/her attention may deeply perturb him/her because of his/her monotropsim.
In the application context, our architecture aims to bring flexibility and modularity in the individualized rehabilitation of children with autism.In the next section we present a part of our platform which observes children and analyses his visual attention.

3.5 The AutiSTIC platform

In the hospital, two rooms have been fitted out, separated by a two-way mirror. In the first room, the psychotherapist observes and annotates at the same time the child's behaviour involved in an activity and the screen observed by the child. In the other room, the child and a tutor, who supports him/her during the time of application, face a computer with a tactile screen, it is inconceivable that a child with autism uses naturally a mouse. Two cameras record his/her behaviour, one recording the child and his environment, the second one is the camera of the eye and gaze tracking system (Figure 3.2). Concerning applications, we have implemented the models presented section 2.2; these models communicate with applications specially dedicated to children with autism (see Figure3.2), for instance, the *hello hidden* game presented next.

Figure 3.2: Left : the hello hidden game developed for the children of La Rochelle hospital. Right : control post of the psychotherapist and the two-way mirror.

3.6 The *hello hidden* game

This interactive game, which we have developed within the context of the autism project, is characterized by simplicity in order to not perturb the autistic child, often sensitive to complex environments. This is why the game have a statical background, contain few objects and are easy to use. Nevertheless, each object has several behaviours in order to allow the control of execution according to the behaviour of each child. The goal of the game is to allow autistic children to reach by interactive manipulation the competences of perception, motor function, spatial and temporal representation... Figure 3.2 shows the game interface of *hello hidden*. This game allows to use one or more balls of various colours on the screen. These balls appear in a frame that is displayed in fullscreen. There are two kinds of balls:that stands in all screens

- The small ball, called *cursor*, which the children can handle by applying a pressure on a touch screen.
- Big balls of various colors which remain motionless. The interaction between the cursor ball and the big balls contains two possibilities: Either the cursor ball disappears when it becomes near big ball and reappears when it goes away, or it stops its progression when it arrives at the periphery of a big ball and joins with it.

The objectives of this game vary according to various situations which occur. In the case of the presence of only the cursor ball, its elementary use allows the child to establish a relation between a direct motor action (to touch the screen) and the effect produced (movement of the object). In the case where one or more big balls are present on the screen and the cursor ball disappears when it becomes near big ball, the objective is to analyse the capacity of the child to represent hidden objects and to act to make the cursor visible.

3.7 Conclusion

We have implemented the architecture presented section 2.5 within the framework of the AutiSTIC project. In the first step, we have developed a platform which ensures the reasoning process and the treatment of exceptions. For the last one, we have developed an agent based system (with DIMA) which observes the child's actions during the session and reacts at each exception about the behaviour of children by modifying the protocol. In the second step, we have developed an interface that allows the expert to define the activities (Figure 3.3-left), the cases and directives. These information as well as the profiles of children are stored in a data server. Finally, we have implemented the models of attention presented section 2.2.

Our platform can use, in real time, information concerning the explicit behaviour of the child (mouse and keyboard events) and his implicit behaviour (movements of the face, gaze...) in order to estimate the degree of carelessness of the child and to adapt the activity as well as possible. We use these annotations, done with *L3IAnnote*, in order to make automatic measures and to validate our model of inattention. Our software, installed both in academic than in medical sites have allowed us to confront our model and the reality of children in front of a computer. The results obtained with children who have took part to our study (three) are very interesting and promising. We have obtained the confirmation of an inverse bath-tub curve, but this number will significantly increased and the model will also need to be validate on people without autism, yet, it is very difficult to have children for the experimentations, because of the reserve of parents and the small number of children in the medical structure. Currently, we have tested our model on ten ordinary player and a racing game (Figure 3.3-right), here again the results are very interesting. We will continue the workshops with the same children by leaving this time the initiative of the stimuli to the computer, in order to analyse their behaviour.

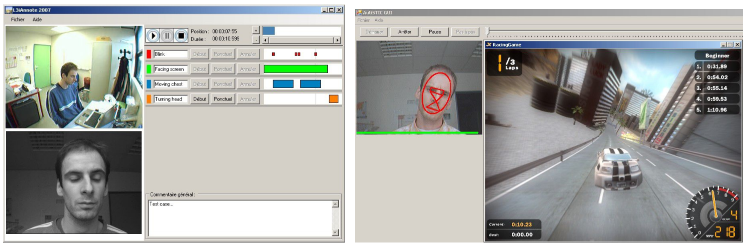

Figure 3.3: Left : L3iAnnote : A video annotation software used to help experts express their knowledge. Right : L3I XNA Racing Game.

Chapter 4

Discussions and future work

We have described our work aimed at the design and implementation of an interactive environment for autistic children, in which the observation system exploit the information of the users eye gaze behaviour. We have proposed a model of attention which allow our agent-based system not to interact with the person in an inappropriate way.
From a gaze tracking point of view, our algorithm provides a robust, easy to use but low accuracy system. Further improvements will aim at improving the system accuracy without compromising the ease of use and robustness. This goal could be achieved, for example, by integrating a continuous calibration process directly into the target application, so that the information concerning the salient objects displayed by the application on the screen and the gaze estimation processed by the algorithm could be fused in order to improve continuously the calibration data (thus the gaze estimation accuracy) during all the application unfolding.

Concerning the AutiSTIC project, we have developed a system which reacts in a dynamic way thanks to the observation and analysis of behaviour. The principle of the interaction lies on the extraction of information according to the spatial and temporal context. The observation and the analysis of behaviour consists in determining the behaviour of children from their actions, by taking into account the experts directives. The results obtained are interesting and promising on the few number of children that have used this system. However, more experiments are needed to validate the proposed models and architecture. As we mentioned, the system we have developed is currently tested in the service of psychiatric of La Rochelle hospital.

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Bibliography

[1] T.E. Brown. *Attention Deficit Disorder: The Unfocused Mind in Children and Adults*. Yale University Press, 2005.

[2] D.J Cohen and F. R. Volkmar. *Handbook of Autism and Pervasive Developmental Disorders*. Wiley, 3rd edition, 2005.

[3] M. Maislin G. Dinges, D. Mallis and J. Powell. Evaluation of techniques for ocular measurement as an index of fatigue and the basis for alertness management. Technical Report Report No. DOT HS 808 762, Final report for the USDOT, National Highway Traffic Safety Administration(NHTSA), 1998.

[4] M. Fabri and D.J. Moore. The use of emotionally expressive avatars in collaborative virtual environments. In *Proceeding of Symposium on Empathic Interaction with Synthetic Characters, at Artificial Intelligence and Social Behaviour Convention 2005*, April 2005.

[5] C. Gepner, B. Deruelle and S. Grynfeltt. Motion and emotion: A novel approach to the study of face processing by young autistic children. *Journal of Autism and Developmental Disorders*, 31(1):37–45, February 2001.

[6] J. James. *The Principles of Psychology*. 1890, (1983).

[7] M. Knaan D. Kaminski, J.Y. Teicher and A. Shavit. Head orientation and gaze detection from a single image. In *International Conference Of Computer Vision Theory And Applications*, 2006.

[8] F. Kaplan and V.V. Hafner. The challenges of joint attention. *Interaction Studies*, 7(2):129–134, 2006.

[9] J.and Harsh J.D. Leaf, R. McEachin. *A Work in Progress: Behavior Management Strategies and a Curriculum for Intensive Behavioral Treatment of Autism*. Different Roads to Learning, New York, 1999.

[10] M. Mallis. *Slow Eye Movements as a Potential Measure of Fatigue and Alertness*. PhD thesis, NASA Ames Research Center, Human Factors Research and Technology Division, 2004.

[11] Shea V. Schopler E. Mesibov, G.B. *The TEACCH Approach To Autism Spectrum Disorders*. Springer, 2004.

[12] M.P. Mostert. Facilitated communication since 1995: a review of published studies. *Journal of Autism and Developmental Disorders*, 31(3):287–313, June 2001.

[13] M. Murray, D. Lesser and W. Lawson. Attention, monotropism and the diagnostic criteria for autism. *Autism*, 9:139–156, 2005.

[14] R.J. Schopler, E. Reichler and M. Lansing. *Stratgies ducatives de lautisme et des autres troubles du dveloppement*. Masson, 1988.

[15] K. Estraillier P. Sehaba and D. Lambert. Interactive educational games for autistic children with agent-based system. In Springer Lecture Notes in Computer Science (LNCS), editor, *4th International Conference on Entertainment Computing*, number 3711, pages 422–432, Sanda, Japan, September, 2005.

[16] V. Sehaba, K. Courboulay and P. Estraillier. Interactive system by observation and analysis of behaviour for children with autism. *Technology and Disability*, pages 181–188, February 2007.

[17] J. Zhu and J. Yang. Subpixel eye gaze tracking. *Proceedings of the 5th International Conference on Automatic Face and Gesture Recognition*, 00:0131, 20-21 May 2002.