A new concept for visual aids: ”ViSAR” Visual Signal Adaptive Restitution

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Abstract— **This paper introduces a new visual device concept for patients with partially sight loss named Visual Signal Adaptive Restitution (ViSAR). This new concept adapt the signal visual itself to the patient's visual discomfort in real time. While most device tends to compensate for physiology anomaly, ViSAR concept allows to improve the patient-signal interaction and to favor an active vision. This system is the first interacting with eye movements and adapting signal to patient cognitive behavior. Patients do not do anything, ViSAR adapts visual signal to patient's visual discomfort without changing visual and referential reflexes. This new concept involves at the same time engineer, ophthalmologic, optometric and cognitive competencies. ViSAR concept offers a new visual device generation satisfying the growing needs in assistance technology.**

I. INTRODUCTION

Prevent blindness America reported that approximatively 2.5 million Americans over the age of 40 has moderate visual impairment and an additionnal one million has severe impairment, including roughly 300 000 who are blind [1]. The leading cause of vision disability is age-related macular degeneration, which affects high-resolution vision. This pathology constitutes the first causes of blindness in the world [2]. This pathology is marked by the presence of a central scotoma, masking the central part of the observed visual scene. This loss of central vision (CFL) affects for example the ability for reading, recognizing face, watching television, and driving. At the moment, visual devices magnify or enhance the signal to improve it detection. These devices minimize physiological deficits but involve another constraints limiting patient visual performance. These constraints are sufficiently important to reduce device visual benefits. In this paper, we presents a new concept of visual device globally more efficient.

II. THE HUMAN-DEVICE INTERACTION

The increasing of the visual pathological frequency had favoured the development of new technology to help visual deficiency patient. However these devices give various results and patient may need several different aids to deal with a variety of identification requirements. No precisely explications were notify but we can find some reasons if we consider visual deficiency problem in a global context. We can define three steps in the visual deficiency architecture (Fig. 1) : Firstly physiological anomaly constitutes the active principle of his deficit. This anatomical parameter participated to the codage of a static vision i.e. detection of the signal. Secondly, this deficit penalyzes the patient in the way to interact with his environment. This dynamical interaction, patient-image, is break at the same time by qualitative and quantitative loss of the signal. Signal integration is then limited by the reduction of patient action on this limited signal, penalyzing his active vision. Active vision is a way for patients to exist in his environment. Thus and thirdly patients become awake of their handicap status in their society by the limitation of this ”active vision”. Patients can interact anymore efficiency with his society then limiting their integration.

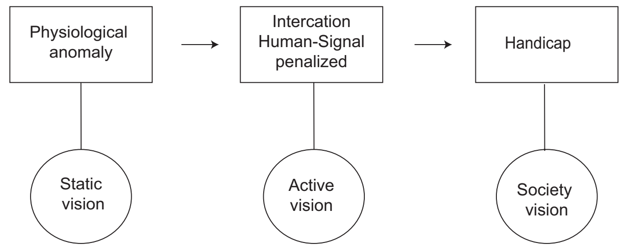

Fig. 1. From physiological anomaly to handicap situation

A. Most devices favor static vision

A central retina lesion masks signal present in the patient central field. Then, patients can catch visual signal only on their peripheral retina. However, retinal peripheral physiological sensibility differs central retina by a reduction at the same time of contrast sensitivity and visual acuity [3] [4] [5]. This is essentially these physiological constraints that devices try to compensate. Thus, visual devices enhance, magnify the signal quality helping patient to perceive peripheral signal [6] [8] [9] .

Various systems were conceived related to functional visual task and wished signal quality (Fig. 2). So, visual optic aids, as for example microscopes, spectacles or optic hand systems allow to magnify signal in function of the remaining visual acuity. Systems as telescopes, closed circuit television (CCTV), electronic devices, head mounted display with and without auto-focus add capacity to improve the enhanced signal and increase magnification for a sustained near task. Some authors propose the image enhancement by detecting visually relevant edge and bar features in an image to produce a bipolar contour map [8], a bipolar contrast, white and black to improve the image detection. The Head Mounted Display (HMD) system is the last new innovation concept to perform during near and far visual task,

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Fig. 2. Example of currently visual devices : CCTV, HMD systems

in static and dynamic conditions. The major HMD system is equipped with autofocus camera, variable magnification optics and enhancement electronics [9]. The HMD design frees user's hand. Magnification, contrast, and brightness are under user control. High magnification, working distance and binocular viewing from a natural posture constitutes favorable parameters for acceptance [9].

Despite all these advantages previously mentionned, spectacle, optic or head mounted systems have gained limited acceptance by patients with CFL. Presumed reasons are : the obvious and unattractive appearance of the devices, non ergonomic device [7], the limited effective field of view (field of view decreases as magnification increases) resulting from the need to use slow head scanning movements rather than natural eye movements, and the vestibular conflict caused by the increased motion accompanying head-mounted magnification [9] [11]-[13].

The signal given by all these devices allow to compensate for patient physiological anomaly, i.e, their static vision by displaying perceptible signal. All these devices don't take into account the relation between patient requirements to interfere with the signal for it integration. It is this dynamical and active vision which misses in low vision device conception.

B. *Favor active vision*

The active vision takes into account a dynamic action between patient action and signal integration. Patient is a actor and interacts with the signal to come along and built a semantic coherence of his environment. Until now, the signal enhancement strategies relate to the static vision. The relation between image itself and human dynamical recognition processes has poorly been integrated in visual devices. On the opposite, the signal enhancing penalize all the benefit so that this dynamic by constraining patient to adapt new motor referential and inadequately motor control [9] [14].

Thus, our study proposes to conceive a new visual device favoring this patient-signal relation. It is interesting to speculate on what constitute the device optimum characteristics for low vision patients. The system must take into account the dynamic between patient action and signal integration. The system must react in real time with patient cognitive behavior to interpret patient difficulty to integrate visual signal. So, system would have "eyes" to listening patient and to help in his visual integration.

As opposed to current devices, it is an obligation to give a sensorial input for this system. This input must translate where patient look and what he doesn't perceived. The output

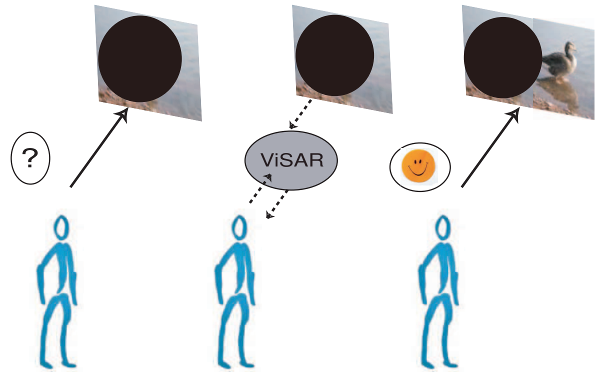

Fig. 3. ViSAR system observes, interprets and restitutes signal favoring recognition

of this system will display signal elements, initially masked and important for it integration. It is possible to use an eye tracker system coupled with an image presentation. Eyes are a strong cognitive input which we have implement in our new concept.

To summarize, this device must have proprieties to observe patient, to interpret his visual difficulty and to act to compensate for his visual discomfort (Fig. 3) . We can then qualified this device as an animated device whose capacities are to adapt patient environment to his visual functioning. In other words, this system will be a servant for patient controlled unconsciously by patient eye movements.

C. *The handicap*

The handicap sensed by patients depends on the deed of Patient-Signal interaction. If patients succeed to interact and understand easily and quickly their environment, their handicap would less sensed. Thus, our new concept tend to reduce patient handicap by favoring this active vision.

We have elaborated this system taking into account this innovative concept. Now, let's more precisely this concept.

III. THE VISAR "VISUAL SIGNAL ADAPTIVE RESTITUTION" CONCEPT

ViSAR concept is an animated device which observe patients to interpret their visual discomfort in order to restitute a new signal. Signal is preliminarily displayed on a presentation screen (computer or spectacle screen). This concept uses eye movements analyse to control patient cognitive integration and restitute the signal. So, this system has advantage to assist patients without formulate a request.

We can determine three important steps in this new low vision device conception (Fig. 4).

1) First : our system must be able to observe patient.
2) Secondly : from this data, our system must interprete patient cognitive discomfort.
3) Thirdly : our system must help patient in his action by restituting a new signal.

A. Patient observation

The innovation is the use of a system which observes continuously patient cognitive behavioral. This system is constituted of an eye tracker apparatus. This technology allows to locate eye position on a visual signal with a great precision (<0.5 degree) and in real time. Eyes are a strong cognitive sensorial input. The determination of the visual interest zone and another parameters as time fixation, saccade size or number of fixation translate patient motivations and his difficulties to capture the interest signal.

B. Interpretation of the patient cognitive discomfort

Patient with CFL losses central signal. We mean this information loss breaks signal detection and then it integration. It is possible to define this not perceived signal part by implementing patient clinical data in our system. With first step, we kwon where patient fixate, i.e. the patient view line of the signal. A clinical examination, named campimetry, can determine angular location and dimension of the scotoma in the same referential as eye position. Thus we can located easily scotoma position on the fixate signal from eye positions and campimetric data. Scotoma position determines also the limitation of the not perceived signal. Once is detecting the not perceived signal, an analyze of the semantic signal content would allow to define the degree of the integration difficulty from masked (under scotoma) and visible (outside scotome) signal.

C. Signal restitution

An important signal loss penalysed patient signal integration. Then we plan to implement in our system the restitution of the masked signal of a visible visual field in real time. The availability of the signal reconstitutes a visual coherence favor detection and recognition. So, ViSAR concept is to adapt signal in function of the visual discomfort defines in step two. Restitute a signal ask to define a location and the nature of signal elements to display. The originality but too the difficulty of this concept is to transpose the optimal cognitive information in a new signal activating it recognition and comprehension. The signal restitution must equal human intelligent processing.

For example, the restituted signal must not be deformed, as tested by Wensveen [15] or Ho [16]. The image deformation disrupts low and high level of recognition processes reducing visual performance. Our first experiment have shown that visual performance obtained with this new system is very sensitive to the way masked signal is make visible[18]. Our best condition is observed when displayed signal translates human optimal cognitive processes. In some case, signal restitution penalyzed more patient if new signal is too little, complete or unessential. This new system can improve patient visual performance provided that the system understands patient cognitive processes to precisely act.

IV. Application Examples

The frequently discomfort related by patients is the non ability to read. The reading speed is considerably reduced for

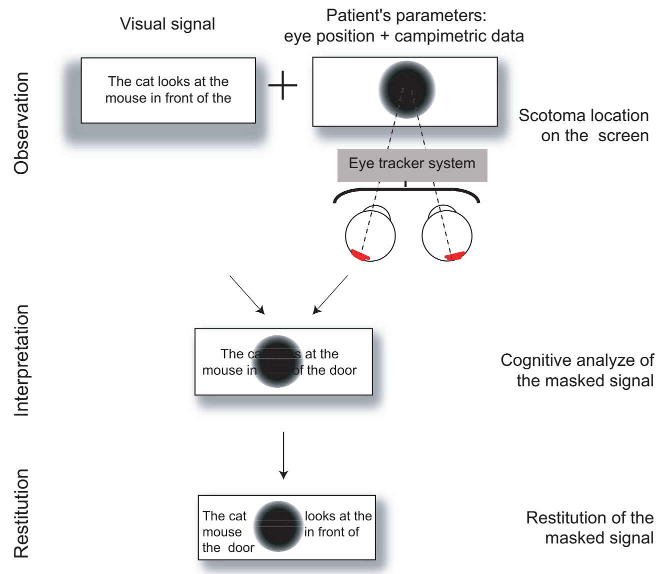

Fig. 4. ViSAR concept architecture

patients with central field loss [6]. Fig. 5 represents texts as it could be read by a healthy subject (without scotoma), by a pathological subject (with scotoma) and by a pathological subject using ViSAR concept.

In pathological condition, the text is partially masked with the scotoma. Text comprehension is difficult. Patient must move continuously his scotoma to make visible the masked signal. The secondly text represents the image with application of the ViSAR concept. When patient fixates zone of interest in the text, all visual signal masked under the scotoma is visible outside the scotoma. This new visual signal display limits visual signal search and improve signal location and comprehension [18].

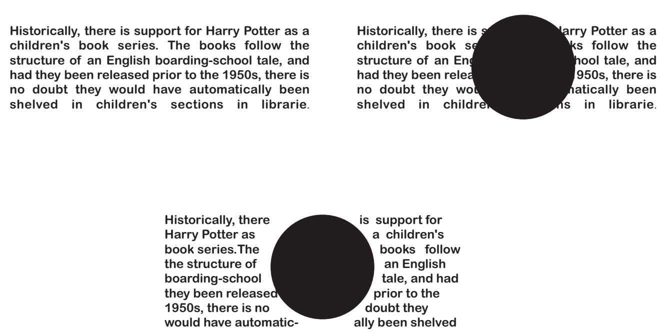

Fig. 5. Reading condition example. Left: normal condition (without scotoma); Right: pathological condition (with scotoma); Below: pathological condition using ViSAR concept.

This concept can be used in static condition (reading) and also constitutes a travel visual aid and/or facilitates social integration. A nonperceived obstacle on the road or not recognized face of our neighbour handicap strongly patients. For example, Fig. 6 represents patient difficulty to recognize face of a person. Scotoma masks all the face. The use of

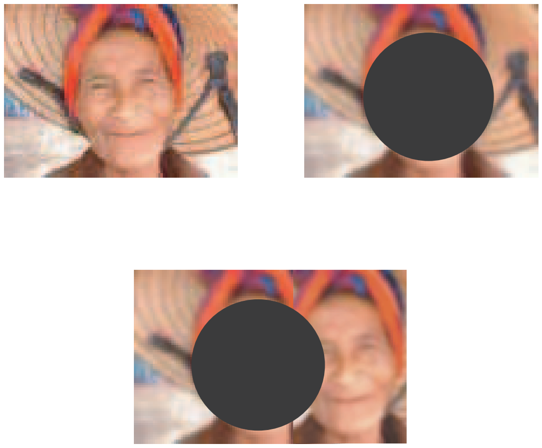

Fig. 6. Face recognition example. Left: normal condition (without scotoma); Right: pathological condition (with scotoma); Below: pathological condition using ViSAR concept

ViSAR concept allows in real time to perceive all face visual elements without ocular adaptation for patients.

A. *Perspectives*

The ViSAR concept tends towards translate human intelligence behavior in a new signal. This system adapts signal to patient visual conditions in real time. The goal of this system is to facilitate signal detection and integration without change patient cognitive reflexes. This new concept offers new hopes for patient presenting visual scotoma. This condition avoid inadequately and blindly visual search of the masked signal as we observe with currently devices. ViSAR is an animated device with a sensorial input which reacts in real time with patient visual needs. It brought an intelligent signal controlled by eye movements. This symbiosis is transparent for patient. With ViSAR concept, we give new intelligent eyes to device.

This concept requires a understanding of the pathological subject cognitive processes. Our first experimention has shown this new visual servant is efficient only if it restitute an optimal signal for recognition. Restituting a signal no enough complete or unessential can slow patient's performance. The device intelligence must be equal human intelligence.

This project consider the patient as a whole entity. This characteristic makes this device personnalizable and usable in case of all pathological evolution. It is the first concept taking into account location and dimension of scotoma. ViSAR uses new technology allowing to take into account new sensorial input. Evolution and progress of technology associated with deepening of human cognitive intelligence allow to built the new visual device generation. Multidisciplinary competencies comfort device acceptance by patient.

V. Conclusion

This paper has introduced the ViSAR concept, a new low vision device for patient with partially sight loss. This new device has propriety to enter in the patient cognitive intelligence to adapt consequently an optimal signal favor recognition. We can consider this device as a servant which observes, interprets and helps automatically patient without patient requests. As opposed to currently devices, our device favor patient active vision. The patient remains actor and limits then his handicap. This new visual device generation controlled by eye movements constitutes new hopes faced with growing evolution of visual deficiency population.

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