MVA2000 IAPR Workshop on Machine Vision Applications, Nov. 28–30, 2000, The University of Tokyo, Japan

8—24

Comparison of Some Vision Systems for Blinds.

Edwige E. Pissaloux
Lab. Robotique de Paris
& Université de Rouen
Edwige.Pissaloux@robot.uvsq.fr

Hichem Bouayed
Laboratoire de Robotique de Paris, CNRS

Samer Abdallah
FEIT,
Australian National University
Australia

Abstract.

The paper addresses an analysis of two elements necessary for vision systems for blinds and robots definition. One of them is an analysis of some most popular and advanced projects of technological assistances for blinds' independent and secure displacements in non-cooperating environment,. The second is an analysis of human scene perception characteristics. The analysis results in conceptual principle definition which should be integrated in technological assistance for blinds based on artificial vision only. Intelligent glasses, presented in this paper, are one of them. The intelligent glasses offer a global environment perception, fixed and moving obstacles detection, and tactile representation of them. Blinds can than know at any time, by small tactile interface fast scanning , where is the free place in their nearest spatial neighbourhood. All the environment analysis and interpretation are based upon two (general, and not only stereo) images.

The proposed system design principles can be easily simplified for humanoid robots.

1. Introduction.

There is more than 180 millions of blinds over the world, and, according to the World Health Organisation [OMS1999], the world population becoming older, this number will double in next twenty years. Consequently, with technology progresses (especially with the advent of nano-technologies) it seems possible to envisage intelligent systems, light and not expensive, which can help blinds to move in independent and safe way in any (not only co-operating) environment.

This paper proposes an overview of some, most promising and advanced prototypes of «vision systems» for blinds, and points out possibilities for new device design integrating the latest technology progresses, especially in the development of nano-technology.

The paper is organised as follows. Section 2 proposes an analysis of some most popular and advanced projects of technological assistances for blinds. Section 3 provides some essential characterisation of human scene perception system. Section 4 proposes a definition of a non-invasive vision system for blinds, named intelligent glasses, and based upon principles listed in section 3. Section 5 encompasses some final remarks and addresses the project status.

2. Analysis of some technological assistances for blinds.

There have been several vision aids designed for the blinds so far ([Bach00], [PB00], [GP95], [FMN94], ...). They can be classified in two groups : invasive and non invasive systems.

Invasive systems establish the physical contact between human body convenient part and hardware device. Invasive systems can be of two types : one trying to quantitatively improve the human eye perception by electric stimulation of the optical nerve, and second which electrically stimulate different parts of human body (stomach, back, ...) according to the fact that the brain is able to correctly interpret different representations of the same information transformed into convenient electric signal patterns ([Bach72]).

The Esprit MIVIP project (MIcrosystem based Visual Prosthesis) [Esp99] aims to design a prosthesis prototype which will be directly connected to optical nerve ; via stimulation of non totally destroyed nerve, the blurred image can be transmitted to the brain and interpreted.

The Oslo University (Sweden) vision system for blinds uses the X rays in order to improve the quality of images registered by the sick optical nerve.

Non-invasive systems are based upon sensory substitution. The sensory substitution most frequently used are : sight —> vibrations, sight —> sound, sight —> electrotactile (skin) stimulations, sight —> tongue electrotactile stimulation,...

These systems are also designed by electronic travels aids (ETA). Frequently, the ETA try to improve a classic white cane by integration of new sensors (laser, sonar, odometry, compass, GPS, ...). Additional sensors guide blinds when they move via local obstacle avoidance.

Mitchigan University : NavChair, Navbelt, Guide cane ([Bor97], [FBE94]) ; Sonic guide ([Kay85]) ; Paris 6 University, Robot guide Dog ([MKI93])... are few examples of such Robotics aids ([GP95], [FMN94]). The Kobe Design Research Institute cane associated with blinds' intelligent guide on sidewalks will provide to blinds more static «social» data implemented on our streets. They allow also blinds to continuously follow the classic guide ([Hir99]), when they move. European Universities Consortium MOBIC system ([FR00]) tries to assist blinds displacements by providing them tools using "train principle" : once the blind "on board", he/she cannot change the final goal to reach, thus he/she cannot progressively learn his/her environment, and increase his/her autonomy.

All non-invasive systems provide the local knowledge of environment ; the (nearly) global (similar to human) environment perception should be obtained via the environment scanning, what is a complex and time and energy consuming operation.

Moreover, these systems provide data on static obstacles only, and do not detect (or event do not help to detect) the moving obstacles.

Almost all of the systems are not able to detect all four elements necessary for blinds secure and independent displacements : reference surface, obstacles located in 3D space above the reference surface (up-stairs, hanging obstacles, ...), obstacles located in 3D space below the reference surface (holes, down-stairs, ...), and finally obstacles on reference surface. Usually, the systems provide the recognition and assistance for first and forth obstacle types. Therefore, blinds learn the global environment after a (happy or unhappy) experience : obstacle (virtual or real) touch.

Furthermore, some of the proposed ETA introduce the noise (in any sense) to the environment (becoming dangerous for blinds and for others (laser)), or simply perturb the true environment perception. Many of these systems are complex : a long and complex trainings (sometime even too difficult to sighted people !) are necessary ; moreover, the blind become totally depended when the system doesn't work anymore (for any reason).

How the above remarks match to human scene perception principles ?

3. Some characterisation of human scene perception system.

We try to identify the most pertinent characteristics of human image acquisition system.

Two eyes facing (usually) our moving

direction are placed on a certain distance above the walking (reference) surface. The eyes, via the stereoscopy, allow to register the observed, (nearly) global scene very rapidely.

The brain analysis system recovers depth information, object high information, and identifies moving and fixed objects.

The human vision system is passive : it gets the information from the environment and do not produce new, environment perturbing and/or modifying, data.

The environment is not cooperating, i.e. there is no « universal » cues implemented in it in order to be able to « see ».

All the above characteristics should be included in vision systems assisting blinds (or robots) in their displacements.

However, it seems that the vision system for blinds (or for robots) displacements should not mime exactly the human perception systems, and above all, do not provide the exact real world representation.

4. Vision system architecture — « intelligent glasses ».

Figure 1 outlines the « intelligent glasses » system.

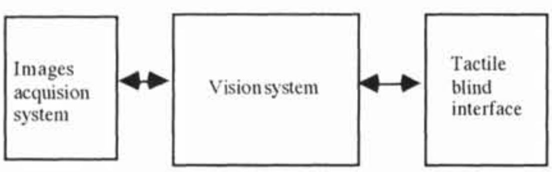

Figure 1. Intelligent glasses — functional blocs.

The whole system is defined with three functional blocks :

• image acquisition provides a pre-processed stereo—images to vision system ; it also enhances the quality of images;

• the vision system analyses the obtained images (stereo-matching, obstacle detection, moving object tracking, ... [PLC001], [PLC99]) and determines the blinds nearest global pertinent environment representation;

• the tactile blind interface communicates the environment representation to user which can locate static and dynamic obstacles.

Stereo-cameras associated with intelligent vision system — constituting «intelligent glasses» — provides global, and pertinent information for blinds (the usage of a 3D camera is prohibited because of their cost ; moreover, the depth information provided by such camera can be easily recovered via some fast and reliable processings ([PLC99], ...).

All functional blocs of intelligent glasses seem correspond to our present understanding of human vision systems work.

5. Conclusion.

This paper has proposed few design principles, and a definition of a non-invasive vision system for blinds. By providing a convenient (nearest) global pertinent environment representation, blinds can identify fixed and moving obstacles, and move in secure way. Moreover, having a simple (internationally understandable) representation of their global nearest environment, they can plan their trajectory thus they get more freedom, and independency.

Furthermore, the proposed system provides to blinds a confirmation of their environment understanding. Consequently, blinds can continue to move, even if the system does not work any longer.

The proposed system offers to blinds the total control of their independent displacements, therefore they can participate more actively in social life (work, for example).

Furthermore, the proposed vision

system can be used for autonomous robots (such as Sony AIBO robots, «human» robots, ...). Indeed, only the tactile blind interface should be conveniently simplified.

The proposed system of «intelligent glasses» is under simulation on a PC with Java technology.

6. Acknowledgement.

We gratefully thank all supporters of this project : CNRH (Comité National Français de Liaison pour la Réadaptation des Handicapés), AVH (Association Valentin HAüY pour le bien des aveugles), Ministère de l'Emploi et de Solidarité.

7. Bibliography.

[Bach72] Bach-y-Rita, Paul, Brain Mechanisms in Sensory Substitution, Academic Press, New-York, 1972

[Bach00] Bach-y-Rita, Paul, Kaczmarek K., A., Tyler M., E., A Tongue-based Tactile Display for Portrayal of Environmental Characteristics, in L. Hettlinger and M. Haas (Eds), Psychological Issues in the Design and Use of Virtual and Adaptive Environments, Lawrence Erlbaum Associates, Mahwah, NJ

[Bor97] Borenstein, J., Design of an intelligent cane for blinds guidance, IEEE Int. Conf. on Robotics and Automation, Albuquerque, USA, April 21—24, 1997, 1283—1288

[BP002] Bouayed, H., Pissaloux, E., Projet « Lunettes intelligentes », Proc. Nat. Workshop of Young Researchers, CNRS/GDR-PRC ISIS, Paris, 16—17 mai, 2000, pp. 117—120

[Esp99] MIVIP, Microsystems based Visual Prothesis, Esprit project LTR 22527

[FBE94] Feng, L., Borenstein, J., Everett, H., R., Where am I ? : Sensors nad Methods for Autonomous mobile robot, Tecn. Rep., UM-MEAM-94-21, Mitchigna Univ., 1994

[FR00] Fritz, S., Rainer, M., Raab, A., Strothotte, Th., User Interface Design for a Travel Aid for Blind People, Repport, Univ. of Magdeburg, Germany, *(to appear)*

[FMN94] Furuno, F., Matsuda, H., Nagata, K;, Opto-electronic cane for mobility aid, Proc. Int. Conf. on Mobility, Melbourne, Australia, Jan. 31 — Feb. 4, 1994

[GP95] Gill, J., M., Petri, H., eds. Proc. Int. Conf. on Orientation and Navigation Systems for Blinds Persons, Hatfield, U.K., Feb. 1—2, 1995

[Hir99] Hirano, K., Design Research Institute, Kobe Univ., November 1999

[Kay8[] Kay, L., Sensory Aids to Spatial Perception for Blinds Persons : their Design and Evaluation, in [WS85], 125—139

[MKI93] Mori, H., Kotani, S., Ishii, K., A Guided Dog Robot Project "Harunobu", Proc. Int. Conf. on Advanced Robotics, Nov. 1—2, 1993, Tokyo, Japan

[OMS1999] Organisation Mondiale de la Santé, http://www.who.int/

[PB001] Pissaloux, E., Bouayed, H., An analysis of existing technological aids for blinds, Research Rap., LRP, March 2000

[PLC001] Pissaloux, E., E., Le Coat, F., Tissot, A., Durbin, F., *An adaptive parallel system dedicated to projective image matching*, IEEE ICIP2000, Vancouver, Canada, 10—13 Septembre, 2000

[PLC002] Pissaloux, E., E., Le Coat, F., *A^3C and its Application to Spatial Optimization of a Parallel Architecture dedicated to Image Matching*, 3rd. Int. Conf. on Computer Vision, Pattern Recognition & Image Processing, Altantic City, USA, 27 février—3 mars, 2000, pp. 184—187

[PLC99] Pissaloux, E., Le Coat, F., Bonnin, P., Tissot, A., Durbin, F., *Design and optimisation of a Parallel Heterogenous System for Aerial Image Matching*, IEEE Int. Conf. on Image Processing (ICIP'99), Kobe, Japon, Octobre 25—28, 1999.

[PBA00] Pissaloux, E., Bouayed, H., Abdallah, S., Towards a Vision System for Blinds, Proc. SPIE International Symposium on Intelligent Robots and Computer Vision : Algorithms, Techniques and Active Vision, 5 au 8 novembre, 2000 Boston, USA.