Self-Adaptive System for Medical Application

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I. Introduction

THIS work is in the domain of electrical devices for medical applications. In the context of high performance systems and critical applications, a Self-Adaptive System must be able to provide the required high performances regardless the application mode and despite the changing environmental conditions. In our study a Self-Adaptive Systems are designed to be able to monitoring the surrounging environment and adapt themselves to different scenarios and requirements.

II. Device for medical application

Among a broad area of application, healthcare - electronic medical devices - is a domain where these criteria are dominant, especially in the context of the developpment of the so-called ”e-Health” domain. e-Health is a relatively recent paradigm for healthcare pratice, supported by electronic processes and communication. It emcompasses a range of services or systems that are at the edge of medecine/healthcare and information technology, see Figure 1.

The patient may be equipped with one or more sensors, applied on the skin, ingested, or even implanted, which may communicate with an electronic device. This mean there is a need of developping new technics and methods that give to the system the ability to adapt itself to different applications and environmentals conditions, but mostly to the patient who may become one of the most important source of direct or indirect disturbances.

Fig. 1. Examples of healthcare applications

III. Adaptation to the application and the environment

A system use different levels of self-adaptation in order to guarantee its robustness:

- The self-adaptation of a system to an application, the target on which the system is going to work, the patient. To do the job correctly for which the system was designed, it must be placed, fixed surely and safely on a anatomy that can change from a patient to another. Moreover the system must be adapted to the measured parameter or to this parameter on which it acts, to provide an high performance. Considering the whole population, those demographic, systemic and specific parameters can vary widely.

- The self-adaptation of a system to its environment. In addition of the surronding environment (Electromagnetic fields, temperature,...) that can disturb the system, the patient become the environment and may interfere directly or indirectly in the functioning of the system. For example by touching it or by doing an activity that distort the measurement or the action of the system.

The first main challenge is to define references which could be used to assess variations, especially for the second level of self-adaptation. The technical obstacle will be to build those references, which could be an absolute or relative reference and come from single, multiple, direct or indirect measurments. Futhermore measuring those references need to be during normal operation. After finding and getting the needed references, we should find how and where apply correctly the compensation to improve the system characteristics in order to guarantee in all cases that the performances are not compromised.

IV. Developpment of a e-Health system

The main risk factor for the development of glaucoma, a retinal disease leading to blindness (60 million people worldwide), is an increase in the intraocular pressure (IOP). The ocular tonometry is the procedure perform to determine the IOP and the applanation tonometry is the standard method to perfom it. It consists to applanate a constant cornea's area by a force that depends on the IOP. This method provides a punctual measure that is not enough to do a reliable diagnostic. Therefore because of the fluctuating IOP during the day and the night, it can be helpfull for an ophthalmologist to analyse a 24 hours IOP to diagnosed a glaucoma.

We can find in the literature solutions using a sensor embedded in a contact lens for continously IOP monitoring [1][2].

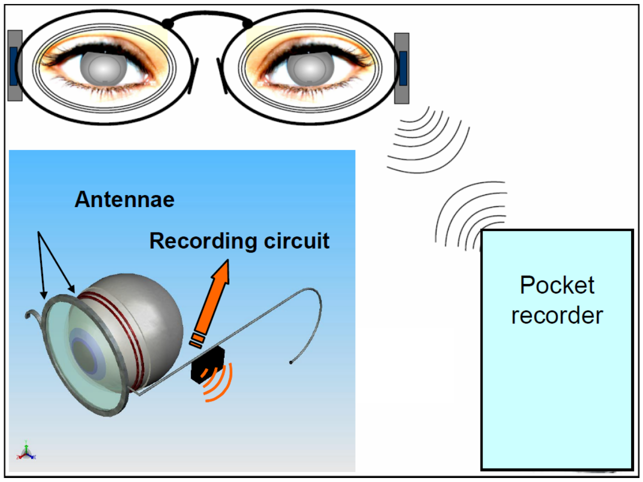

Fig. 2. Conceptual view of the system

The system is composed of tree part: the contact lens, the glasses and the electronic recording. The contact lens is the secondary of a magnetic coupling with the glasses which is the primary and the deformation information of the lens is send through this magnetic coupling. The data are obtained by the ultra-thin micro-fabricated sensor in the lense that allows the measurement of changes in cornea curvature correlated to IOP. The data are sent to the glasses thereafter stored in the electronic recording which is a portable device, see Figure 2.

V. The importants parameters

To adapt this kind of prototype to every patient and make it self-adapted, physiological/anatomical and environmental parameters that can disturb or provide an information to get an high performance system have to be found. Among the range of parameters which play a role, they can be divided in two groups:

- Parameters that are correleted to the IOP or IOP's variations. Among those parameters, some of them are called systemic factor like blood pressure, body's temperature or hormonal actvity. Demographic factors are particulary associeted with the genetics aspect like age, sex or ethnic group. Others factors are more environmental parameters, amount of oxygen in air and air's temperature can influate on the body therefore on the IOP [7].

- Parameters that disturb the measure of IOP. The thickness cornea was the first parameter considered like the most important source of measurement mistakes with the using of the standard tonometry [6]. The eye blinking create strong disturbances by acting mechanicaly when a sensors integrated in a lens is used [8][9]. Heart rate provide the Ocular Pulsation (OP) that is small variation of IOP that can be interpreted like noise. Air humidity define the quantity of water between lens and cornea (whitout eye blinking) and therefore the mecanic behavior of the lens with the cornea deformaton.

VI. Conclusion

The study must now turn to the most important parameters. It was show that the blood pressure is strongly correlated with the IOP and maybe one of the most important source of information in the developpement of a glaucoma [3][4][5]. Therefore the blood pressure may help to provide a better measurement and others usefull informations in the context of e-Health research.

Because the thickness cornea change the behavior of the mechanical deformation of the cornea this static parameters have to be taken into account in conception of a intra-ocular lens sensor and can be integrate during the calibration.

The processing chain between the observed IOP and the real IOP in the eye, passing through cornea deformation and lens deformation, is not full controlled. That is why a dynamic parameter that change mechanical behavior have considered like the air humidity.
Once parameters are chosen, a method have to be found to define where and how obtain the information contained in the parameter and how the information must be applied on the system to make it self-adapted. Knowing the increasing number of patient and e-Health application, the need to conceive methods to make a system self-adapted to wide range of application and environment become stronger.

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