BIO-MEDICAL SENSING USING FIBER OPTIC SENSORS.

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Abstract: The paper presents the results of the Group work in terms of fiber optic sensor system for human psycho-physical activity detection. A fiber optic sensor that utilizes optical phase interferometry or intensity in modalmetric to monitor a patient's vital signs such as respiration cardiac activity, blood pressure and body's physical movements. The sensor, which is non-invasive, comprises an optical fiber interferometer that includes an optical fiber proximately situated to the patient so that time varying acusto-mechanical signals from the patient are coupled into the optical fiber. The system can be implemented in embodiments ranging from a low cost in-home to a high end product for in hospital use.

1. Introduction

The main objective of the project is to improve the safety of the aircraft and road traffic participants and patients of hospitals and clinics specialized and neonates by creating innovative (remote) global methods of monitoring psycho-physical activity detection with the function of autodetect the threats. The Project is co-financed by the European Regional Development Fund within the framework of the 1. priority axis of the Innovative Economy Operational Programme, 2007-2013, submeasure 1.3.1.” Development projects” Contract no. UDA-POIG.01.03.01-14-136/08-00.

The team is working on many different methods, such as: EMFITS, microwave technology, capacitive methods, fiber sensors. The aim of the project is laboratory test existing and developed at the moment of measuring instruments. “Remot” means that the measurement of human's life processes will run without using a physical connection with monitored person. Using developed methods will be concerned. Aviation, pilot health depends not only his life, but also force passenger aircraft. In this case, the contactless pilot monitoring heart rate will enable early detection of a possible disorders of the cardiovascular system, so that it can be immediately directed to the appropriate clinical trials.

Further potential customers problems created by the project system will driver. Detection of scare behaviour of drivers (e.g. fatigue) would allow for immediate reaction in the form of transfer by car to the on-board computer system to the corresponding signal to stop the vehicle. Technology will also remote measure the pulse by clothing, bedding or bandages. Therefore, the another group of customers will achieve effects of projects and clinics were hospital patients suffering from sleep disorders, mental disorders, as well as patients with large wounds, which burnt place prevent placing electrodes ECG. In this way can also be monitored babies is would make it possible to reduce the number of children suddenly moribund during sleep (SIDS) Sudden Infant Death Syndrome.

In this article a fiber optic sensor technology is developed. Emphasis is placed on the problem of feature extraction to reduce all spectral responses to several features allowing simple classification of different perturbations from the human body for continues monitoring of human activity. The identification of specific signals was investigated in the following application settings:

- interferometer fiber optic sensor responses,
- modalmetric fiber optic sensor responses.

The field of signal processing techniques for fiber optic systems is relatively unexplored, however work has been reported in determining optimal techniques for demodulation, denoising of perturbance and identification kind of perturbation for specific, different fiber optic systems.
Simply stated the problem of pattern recognition or classification is that of taking raw data and assigning that data to one of several potential classes and compare the signals known in medical technology like EEG, EKG.

2. The concept of using fiber sensors for the measurement of human activity

In order to develop the monitoring activity based fibre sensor that resulted the following research:
- analysis of the fibre in each interferometric sensor optimal configuration limited to three i.e., Mach-Zehnder, Michelson, Sagnac
- mathematical description of developments in fiber optic sensor in this three configurations,
- numerical modelling of the impact on the microperturbations in the singlemode optic fiber on light propagation in the sensor,
- numerical modelling the impact of the nature and parameters of the light source on the work of the sensor,
- numeric designation of the sensitivity of the sensor,
- the numeric designation response sensor for different location of mechanical disorder, possible in monitoring human activity, taking into account the two types of usage of two different speeds propagation in one site,
- a statement of position fibre sensor in laboratory-configuration,
- modeling the structure of the sensor as possible sensor, the parameter elements of the sensor (assumed target core familiar with fiber transmission technology in order to minimise costs),
  a) the impact of radiation sources used in the work of the work of system,
  b) any products light interference, by for example additional connectors, in the sensor can cause abnormal,
  c) specify length the use of fabric sensing fiber,
  d) to specify an acceptable, with considerations on sensitivity parameters, how secure optical fiber before environmental conditions, because eventually it will be used in the field of medical application,

Conducting the listed research will develop of the final product, which will involve:
- simple construction - use standard configuration of optical sensors,
- reliability of operation, signal response to designate – continuous monitoring of psychophysical processes,
- suitability for parameters of the sensor to commercial uses, primarily for applications e.g. the aircraft, it must be understood in this way that the system can be mounted on the pilot's seat or emergency vest,
- full scalability of the measuring system, including the possible ways of interpreting the results.

3. Experimental results

3.1. Laboratory equipment.

All presented research are carried out on the laboratory bench which Military Academy of Technology, see Figure 1. It covers optic measuring instruments of communication techniques like OTDR-s, spectrometer, power meters, passive elements (couplers, WDM couplers, isolators, etc.). A laboratory measurements was itself by article. To compare and clear monitoring of obtained results served mobile EKG device, displayed in Figure 2.

![Fig.1. The view of laboratory equipment.](image1)
![Fig.2. The view of laboratory reference equipment.](image2)
3.2. For example - experimental results of Mach-Zender sensor

The above presented simulations proved correctness of the monitoring of human activity method and enabled us to construct the sensor. Taking advantage of the above-mentioned conception of the sensor, the Mach-Zender interferometer set-up was built Figure 3 and tested in laboratory conditions in order to evaluate its parameters. The sensor loop had 10m length and was arranged on a special coils of fibers. The polarization controllers placed in the fiber loop allowed us to adjust polarization state of interfering beams. In order to disturb the fiber, a sensor head was placed at four positions on fiber sensor configuration.

The output signals were filtered by means of a RC filter and digitalized. Afterwards, they were registered and send to data processing unit (Fig. 3). The signal processing was carried out by means of a LabView software.

The examples of the Mach-Zender signals for two different position of sensor head of the human body in Figure 4a and 4b, respectively.

4. Summary

We proposed the method of detecting, monitoring and identification of human body signal by means of fiber optic sensor as well as the sophisticated signal processing, utilizing a correlation technique.

We tested our setup for the 10m, 5m, 3m and 1m interferometer sensor loop (sensor head). We received initial results that are consistent with earlier modelling parameters. One of the major problems with using this technology is changing the polarization of light. Therefore, further work on the project are carried out at the fiber modalmetric sensor. This configuration is not affected by reason of interferometric fiber optic systems.

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5. References