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Development of wireless optical CDMA system for biosignal monitoring

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ABSTRACT

This paper investigates the use of infrared technology in healthcare monitoring to develop a mobile medical system. This is because existing technology is generally based on radio frequency (RF) systems, which might suffer from electromagnetic interference (EMI). Additionally, the effect of the radiation field on medical equipment may lead to misdiagnosis. In answer to these issues, optical wireless links between the medical sensors and the receiver in the middle of the ceiling in a hospital room was examined. From the results, the power efficiency of the mobile optical wireless system to ensure the communication between medical sensors and the receiving point was established. Furthermore, the minimum required transmitted power for the required performance was determined to achieve a higher power autonomy. The results also show that the requirements of a healthcare monitoring application for medical nodes of up to 10 nodes, considering a data rate lower than 1 Mbps, can be achieved using infrared technology. The results prove the superiority of the optical wireless technology over the conventional radio-based communication network in healthcare monitoring systems.

1. Introduction

Over the last decade, healthcare monitoring system has been rapidly developed in response to a growing need for high-reliability and high-mobility for the patient while staying in the hospital, as well as, providing high level of safety, fast response and improving hospital staff's efficiency [1,2]. In fact, optical wireless communication (OWC) based on IR technology, is recognized as a complementary solution to RF based systems due to its immunity to electromagnetic interferences (EMI), providing high level of security during transmission. Whereas the induced EMI in the healthcare environment, may cause malfunction to some of the medical devices, which would probably lead to misdiagnosis [2,3].

OWC links can be classified into different schemes according to the alignment and positions of the transmitter and receiver. The simplest scheme is the Line-of-Sight (LOS), which has better power efficiency and lower multipath dispersion. However, LOS requires perfect alignment between the transmitter and receiver, which is not suited to patient movement and scenarios because it is difficult to establish a perfect alignment between the transmitter and receiver while the patient is fully mobile. Therefore, a diffuse scheme is introduced to overcome the alignment requirement in the LOS scheme, which instead, makes use of reflections from walls, the ground, and other reflectors. Nonetheless, diffuse transmission links are

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0030-4026/

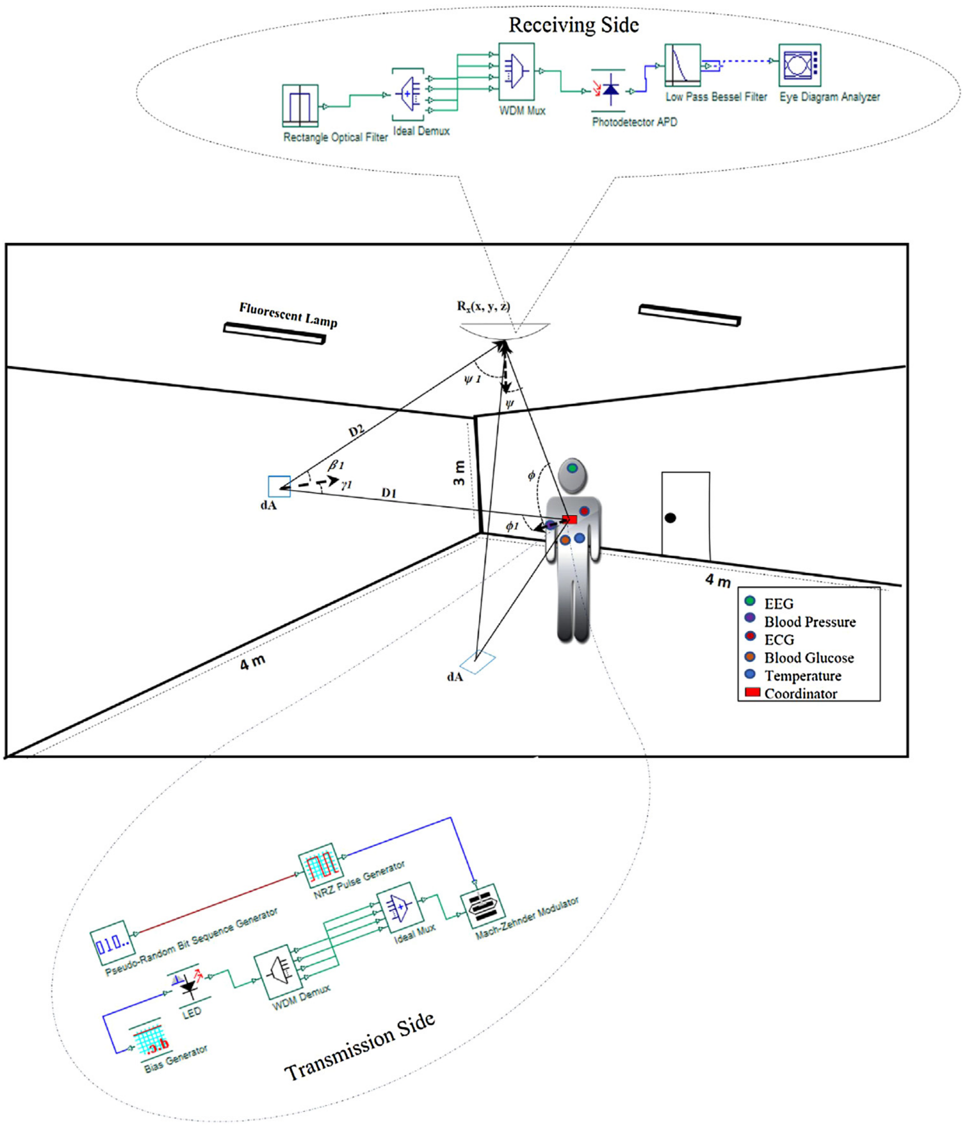

Fig. 1. The architecture of an Infrared channel with OCDMA transmitter and receiver schemes for the proposed patient monitoring system.

usually affected by multipath dispersion (which causes pulse spread and significant ISI), poor power efficiency, and a higher amount of collected ambient light noise at the receiver part [4,5].

In this paper, we investigate the use of wireless infrared (IR) technology in an indoor mobile monitoring system to ensure the quality of transmission between the coupled transmitter with the medical nodes, which might be attached to the patient's body and the established base station on the ceiling of the hospital room. In order to differentiate these nodes, an optical code division multiple access (OCDMA) system based on zero cross correlation (ZCC) code is utilised, due to its simplicity, flexibility, no cross correlation between nodes, and no need for synchronisation between the nodes [6,7]. Additionally, OCDMA system has the advantage of reducing the multiple access interference (MAI) and phase-induced intensity noise (PIIN) which existed in the optical wireless networks when the system is employed with multiple medical nodes.

The paper is organized as follows: in Section 2, we describe the proposed system. We illustrate the channel model in Section 3. Then, we develop in Section 4 the studied system, and the results are analysed in Section 5.

2. Proposed system description

An empty room having a width of 4 m, a length of 4 m, and a height of 3 m was considered. Each wall surface was divided into a number of equal-sized reflective elements with area dA and reflection coefficient ρ. The reflections from windows and doors were considered to be identical to the wall and ground reflections. As shown in Fig. 1, a patient with N medical