REAL-TIME FEEDBACK IN TABLE TENNIS BASED ON 2.4 GHZ WEARABLE WIRELESS SENSOR

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ABSTRACT

The rapid development in technology including wireless communication, microcontrollers and smart sensors makes the monitoring and real time feedback is possible to achieve in different applications including health and sport. This paper presents a wrist mounted accelerometer with RF (Radio Frequency) wireless communication to give a real time feedback to a table tennis athlete during playing. nCore 2.0 and nCore 3.0 CiP (Circuits In Plastic) wearable wireless sensors that are designed in the centre for wireless monitoring and applications at Griffith University are presented. These sensors are used with some hardware and software modifications by adding the 2.4 GHz module. This frequency is popular to use in ISM (Industrial, Scientific and Medical) band. Experiments including checking the best and the clearest acceleration data and sending real time data are conducted. The results showed that this system is feasible to be used for real time data interaction between athletes and coaches.

KEYWORDS: *Wearable Wireless Sensor, Human-Computer Interaction, Digital Systems, Real time Monitoring and Feedback, Accelerometer Data.*

I. INTRODUCTION

Important information can be provided by monitoring athletes in real time using motion sensors and eventually the performance can be improved and the risk of injuries can be reduced [1]. Most sport and health applications based on sensors depend on post processing of data after finishing the action. This paper describes a new approach based on real time feedback between athletes and their coaches. A wrist-mounted accelerometer with RF communication link to a receiver located on the coach's tablet 2 m away allows real time data to be monitored by a coach and instantaneous feedback can be given. The communication system must achieve the suggested distance 2 m. RF module (NRF24L01+) that can be used as transceiver is used in this paper. The coach can send instructions after monitoring the data and this feedback can be interpreted and introduced to the player through different ways such as sound, visual or even vibration in order for the athlete to adjust during training. Real time feedback is important in sports such as table tennis because performance is strongly correlated with technique and the table tennis players try hard to reach the optimal performance. Currently table tennis players depend on video and coaches to improve their technique. Some aspects are opposite to human intuition for example, putting more effort does it mean good technique. Also, real time feedback can provide table tennis player with information to adjust instantly. This system is very useful to use during training in order for a table tennis player to find the most effective techniques to improve performance [2]. This paper is organized as below: in section II the system design is presented. Section III includes the experiments and the results. Finally in section IV conclusions and discussions for future work are described.

II. System Design

In this paper the nCore 3.0 (CiP) and two nCore 2.0 wireless sensors are used. The first sensor is used in the first experiment to check the best and clearest data to send to a coach by recording and analysing the 3-axis acceleration data. The second and third sensors are used for sending and receiving data. Figure 1 shows the block diagram of nCore 3.0 and nCore 2.0. The dotted line block represents the RF module that is added to the nCore 2.0 [3-7]. This sensor is designed and implemented at Griffith University, School of Engineering, centre for wireless monitoring and applications (CWMA). This sensor is implemented based on the microcontroller unit (ATmega324) which is the most popular processor to be used for embedded applications. The memory or the data flash 2 Mbytes is used (AT45DB161D) for data storage. The tri-axial accelerometer is (MMA7331) with ±6g range. The USB to UART bridge is (CP2102). A charger circuit is added to this sensor to charge the 3.6 V battery with a maximum capacity of 240mA [4]. Figure 2 represents the nCore 3.0 wearable wireless sensor.

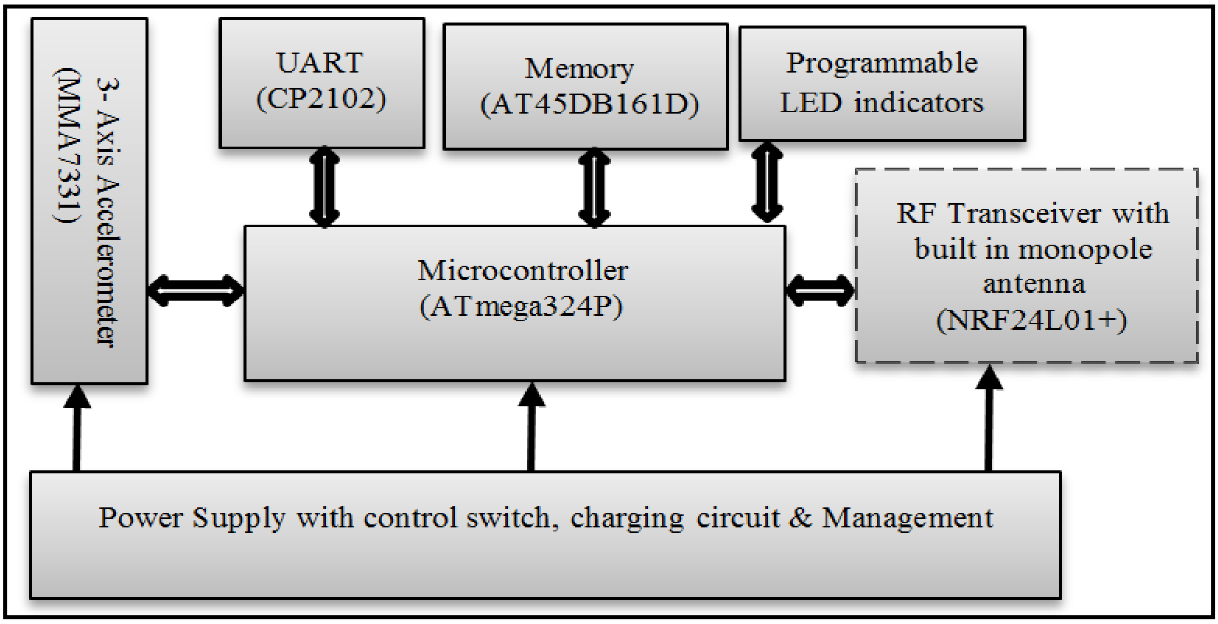

Figure 1. Block diagram of the nCore 2.0 & 3.0. The dotted line block represents the module that is added to the wearable wireless sensor nCore 2.0 [3-7].

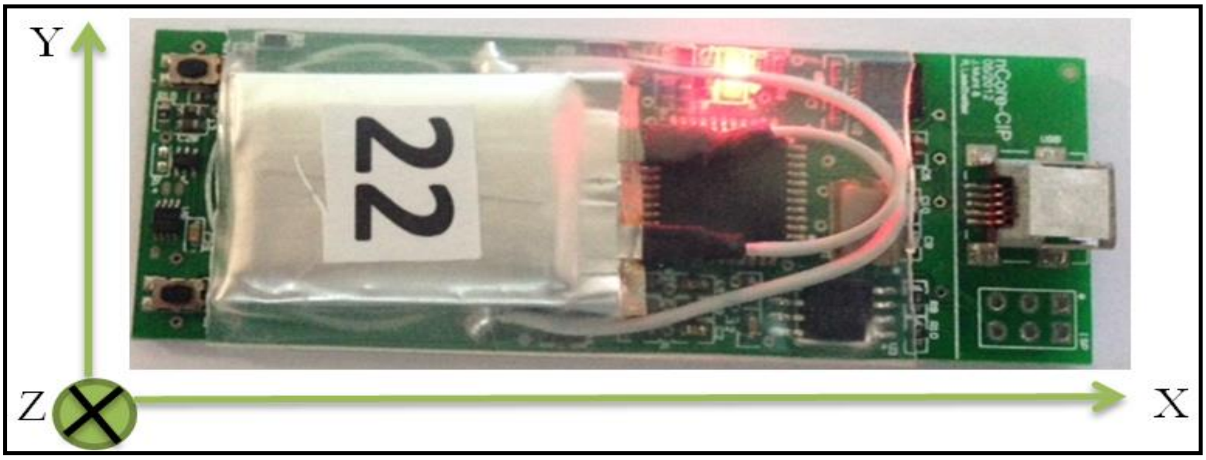

Figure 2. nCore 3.0 wearable wireless sensor.

The main problem with the nCore 3.0 sensor that it does not have expansion ports in order to add the RF module for communication for sending and receiving data. Therefore, for communication and sending data nCore 2.0 wearable wireless sensors are used as shown in figure 3 [5]. This sensor is designed and implemented at Griffith University as well. However, hardware and software modifications are applied for this sensor. One of the sensors is programmed as transmitter and another on as a receiver using C language with Atmel Studio 6.1. The hardware connections for adding the RF modules are also different for the transmitter and the receiver. The module that is added to the nCore 2.0 sensor (transmitter and receiver) is the (NRF24l01+) which is the RF transceiver for the 2.4 GHz ISM band with built in monopole antenna. The receiver sensitivity is -90 dBm and the transmit power is +7 dBm [4].

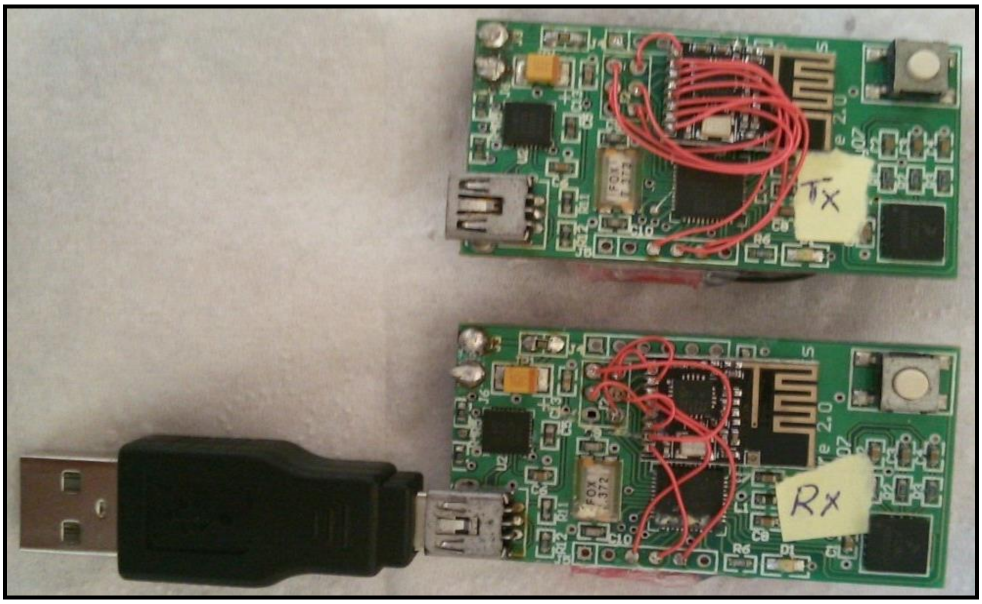

Figure 3. nCor 2.0 wearable wireless sensor the top one is the transmitter which is connected on the table tennis player's wrist and the bottom is the receiver going to the USB port of the coach tablet.

III. EXPERIMENTS AND RESULTS

Experiments are conducted using nCore 2.0 and nCore 3.0 wearable wireless sensors. The first experiment was checking the best and clearest data to be send to a coach's tablet which should be at least 2 m away from the table tennis player. nCore 3.0 wearable wireless sensor is used in this experiment. The sensor is connected on the right wrist of a player so the Y axis of the sensor is parallel to the racket handle, Z is normal to the athlete wrist and X is perpendicular to the athlete wrist. The right handed professional athlete is asked to play for around five minutes performing the strokes including (forehand and backhand push, drive and top spin) and the acceleration data is recorded and saved in the memory to analyse it later. Figure 4 shows a sample results from this experiment which is a short window that is expanded from the overall results and plotted using MATLAB for the three axis acceleration data.

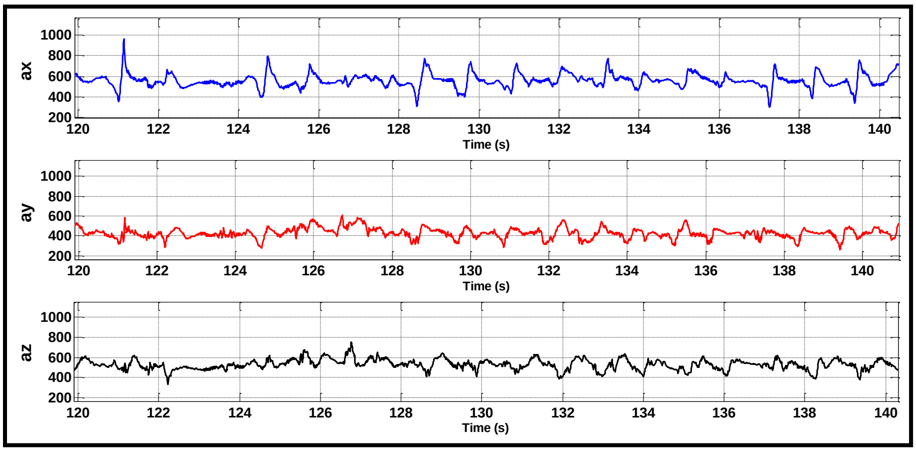

Figure 4. The 3-axis acceleration sample data for a table tennis athlete.

From figure 4, the acceleration data of the X-axis is the clearest and the peaks are obvious. However, data processing by adding a filter can be applied to the acceleration data to remove the noise. The important information which is useful for athletes and coaches such as the speed of the ball, the stroke type and the number of times the racket hits the ball can be determined directly from the raw acceleration signals. Peaks are expected to appears according to the number of times the ball hits the racket. All these information should be able to improve the techniques for the table tennis players.

The second experiment that is conducted was sending real time data to a receiver on a coach's tablet while the table tennis player is plying. In this experiment the athlete asked to play for five minutes and the acceleration data transmitted in real time. The red LEDs on the transmitter nCore 2.0 sensor and the receiver were flashing consequently as an indicator of sending and receiving data. The bit error rate was checked after finishing the experiment by saving the transmitted and the received data on the storage memory of the nCore2.0 at the transmitter and on the coach's tablet where the receiver is connected. Docklight V1.6 is used as a HyperTerminal program to display and save the received data. The percentage of the receiving data was 100% which means that the transmitted data is received correctly and this is coincide with the author previous paper [4]. Data is transmitted wirelessly using the IEEE protocol (2.4 GHz band). The sensor is powered using a rechargeable battery [8]. Figure 5 shows the transmitter and the receiver. The transmitter is connected on the athlete wrist while the receiver with the tablet is used by the coach to see the real time data and send real time feedback.

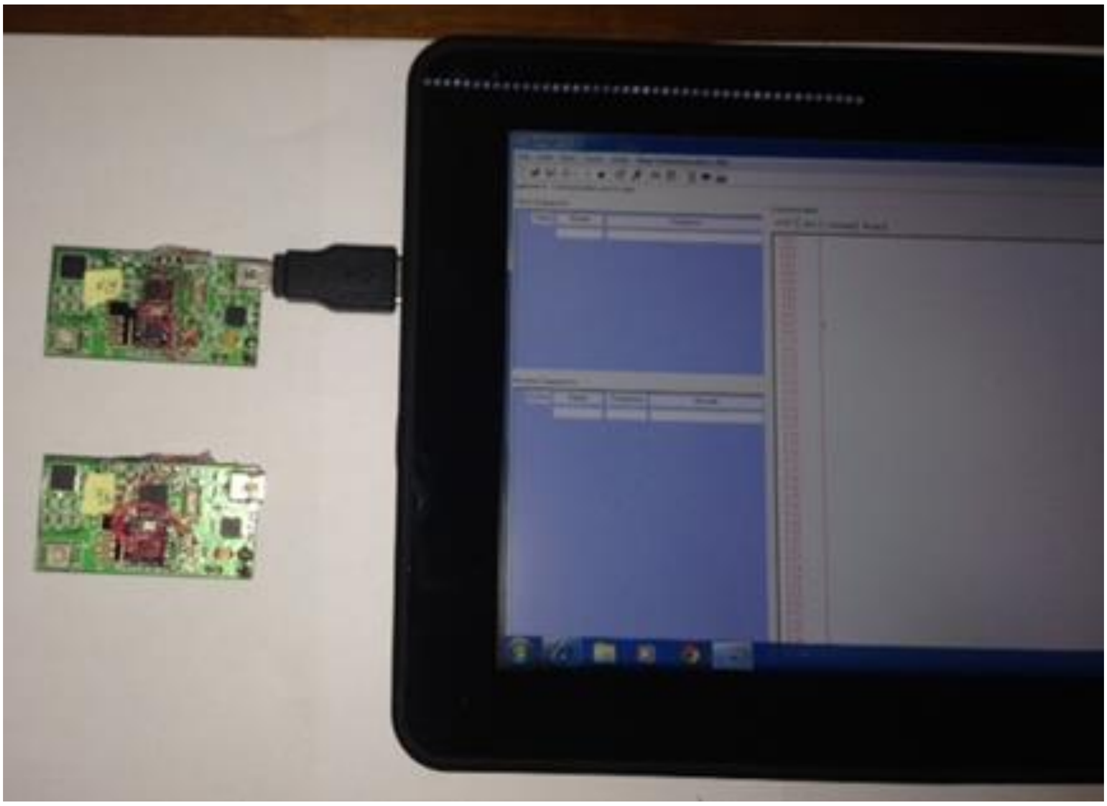

Figure 5. The transmitter and the receiver sensors with the coach's tablet.

IV. CONCLUSIONS AND FUTURE WORK

This paper presents a new approach for real time feedback in table tennis based on wearable wireless sensors nCore 2.0 and nCore 3.0. These sensors are designed and implemented at Griffith University. Hardware and software modifications are applied to nCore 2.0 by adding the RF modules and the sensors are programmed to be one as transmitter and another one as a receiver. Experiments are conducted to check the system feasibility. The first experiment is checking the clearest acceleration axis to determine and calculate the important data. The second experiment is by sending real time data wirelessly from a transmitter sensor on the athlete's wrist to a receiver sensor on the coach's tablet that is 2 m away from the table tennis. The percentage of receiving data and the bit error rate is calculated by comparing the transmitted and the received data. The results showed that the received data was error free for 2 m. For future work the sensors can be programmed using C Language and Atmal studio 6.1 to send important data not just the raw acceleration. Graphical User Interface (GUI) can be designed in Matlab to present the data to the coach's tablet in more professional method for fast interpretation and quick response. Real time feedback to the athlete can be illustrated using light, sound or vibration in order to adjust immediately. RF module with amplifier can be used to support longer distance between the coach and the athlete. All these things can be achieved. This paper proved that real time feedback in table tennis is feasible.

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