Human Body Posture Tracking Using Flexible, Wireless and Low-Power Sensor Nodes

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Abstract— **Human posture tracking is performed using several sensor nodes attached to a subject's body. A Kalman filter estimates the orientation of each of the nodes from the outputs of the sensors. This orientation is then mapped to the appropriate bodypart allowing full body posture reconstruction.**

The design of flexible, wireless and low-power sensor nodes for orientation tracking purposes is presented. Hardware components are chosen based on size and power consumption and software is written to implement a TDMA-like protocol allowing 10 nodes to send 100 samples per second to a base station receiver.

Keywords—**Kalman Filter, Sensor Nodes, Wireless, Low-Power, Orientation Tracking**

I. Introduction

Several techniques are available for human posture tracking. Among them, optical and inertial systems are most common. Optical systems, which use one or more cameras, are restricted to a limited area and require a free view to the subject at all times. Using inertial sensors, human posture tracking can be accomplished by combining several sensor nodes placed on the body. Obviously, these nodes must be designed in an unobtrusive way in order to allow the subject to perform everyday activities and wireless communication insures free view is not required and the range of the system can be controlled.

Each of the sensor nodes in an inertial tracking system must contain a number of sensors

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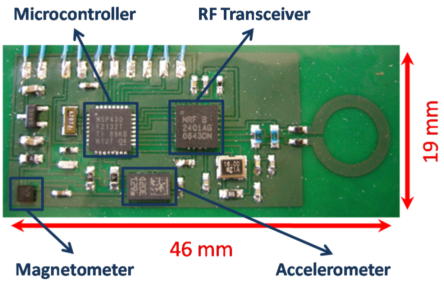

Figure 1. Top view of a fully assembled flexible sensor node.

that allow estimation of the full 3D orientation. Traditionally, 3 types of sensors are used: accelerometers, gyroscopes and magnetometers [1]. We have designed a Kalman filter that estimates full 3D orientation using only accelerometers and magnetometers [2]. This way, gyroscopes can be omitted in the sensor node design, resulting in smaller and less power consuming sensor nodes.

II. Sensor Node Design

A. Hardware

A top view of an assembled sensor node is displayed in Fig. 1. Each node contains a low-power TI MSP430F2132 microcontroller, a low-power Nordic nRF2401 RF transceiver and two fully integrated, 3D sensors: an ST LIS302DL accelerometer and a Yamaha YAS529 magnetometer. A board design was made in a single conductive layer allowing in-house production and assembly of the sensor node on a flexible poly-imide substrate.

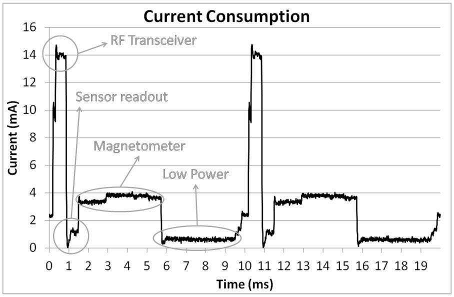

Figure 2. Time graph of the current consumption in the master node during 2 measuring cycles.

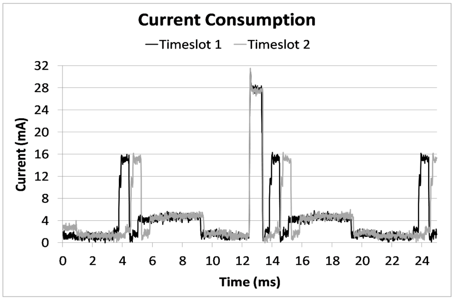

Figure 3. Time graph of the current consumption in two slave nodes during 2.5 measuring cycles.

B. *Software*

The current consumption of the sensor nodes has been minimized by careful implementation of the functionality in order to obtain a maximal battery life. This involves maximal use of low-power modes and interrupts of each component, which is especially valid for the RF transceiver, as this chip generates the highest current consumption when switched on. Therefore, a custom communication protocol based on TDMA has been implemented.

The protocol assumes the presence of a master node which serves as a time reference for the slave nodes. Every 10 ms, the master sends a data package with the output of its sensors to a receiver. The slaves will synchronize to this transmission and, whenever they receive a package, they will transmit their own sensor data in a different time slot. Slaves can distinguish a package from the master from that of another slave as both are transmitted in an other RF channel. In order to limit the active period of the RF transceiver, synchronization with the master is only performed every 256 packets. All packets in between are sent in the correct time slot by relying on a watch crystal.

III. Results

Fig. 2 shows a time graph of the current consumption in the master node during two cycles. Several regions can clearly be discerned and associated to a certain component's functionality. The average current consumption of the entire node was measured to be lower than 3 mA.

Fig. 3 depicts the current consumption of two slaves which have been assigned the first and second time slot. Clearly, both send their data at a different point in time, avoiding collision. The largest peak is due to the RF transceiver operating as a receiver for the master data. This peak is only present every 256 packages and adds about 10 μA to the average current consumption of a slave in respect to the master.

IV. Conclusions

Flexible, wireless and low-power sensor nodes for human body posture tracking have been designed. Careful implementation of the functionality has resulted in an average current consumption of less than 3 mA. A TDMA-like protocol allows 10 nodes to transmit data wirelessly at a rate of 100 Hz to a single receiver.

Acknowledgments

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References

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