Demo Abstract: RatMote – A Sensor Platform for Animal Habitat Monitoring

Jó Ágila Bitsch Link, Thomas Bretgeld, André Goliath, Klaus Wehrle
Distributed Systems Group, RWTH Aachen University, Germany
{jo.bitsch,thomas.bretgeld,andre.goliath,klaus.wehrle}@rwth-aachen.de

ABSTRACT

In this work, we present RatMote, a new wireless sensor node for subterranean animal habitat monitoring. RatMote has been developed for project RatPack, which aims at creating a new method for behavioral research on rats in their natural environment using wireless sensor nodes.

Recent development in microcontroller architecture allowed us to design a sensor node which calculates up to 22 times more operations per mAh than the widely used TelosB node. This significant performance and efficiency increase allows us to perform computationally demanding algorithms inside the node, needed for vocalization analysis, localization, and mapping.

Categories and Subject Descriptors

C.3 [**SPECIAL-PURPOSE AND APPLICATION-BASED SYSTEMS**]: Real-time and embedded systems

General Terms

Design, Experimentation

Keywords

Sensor networks, animal observation

1. INTRODUCTION

Sensor networks have long been considered to be simple devices with very limited computational capabilities, rendering them infeasible for complexer tasks, such as online ultrasound analysis or localization and mapping tasks in highly dynamic environments. We want to challenge that notion and expand the application space made possible by recent developments in microcontroller architectures [1].

In this demo abstract, we want to focus particularly on the use of sensor networks for the observation of highly dynamic subterranean animals, namely the common Norway rat. The animals are equipped with a sensor pack – RatMote – recording their movements and vocalizations.

The widely used TelosB platform [4] employs the MSP430 microcontroller, which, while having very favorable power consumption characteristics, e.g. a 10 µA stand-by current, is optimized for computationally inexpensive tasks. This enables applications like microclimate analysis and simple preprocessing and forwarding. We argue that, while those applications are important stepping stones for making the vision of smart dust reality, we do need to revisit the hardware we use to enable more complex processing.

New applications, like the above mentioned rat monitoring project, require significantly higher computational performance so that complex analysis like FFT and graph matching can be realized. At the same time they have very tight size and weight restrictions. Following current hardware development, e.g. the new Cortex-M3 series, we are able to meet those requirements and thereby greatly reduce the amount of data which needs to be transferred to a base station.

2. RATMOTE DESIGN

The core of the RatMote sensor node consists of a STM32 Cortex-M3 processor and a IEEE 802.15.4 compatible radio module. Fig. 1 shows the current revision of our sensor node. It is equipped with a set of navigational sensors consisting of a 3D accelerometer, a 3D magnetometer and a 2D gyroscope. These sensors allow step detection and path reconstruction even in the absence of anchors or GPS, while the complete setup weighs only 12 g.

The whole sensor node is driven by a reduced supply voltage of 2.7 V instead of a more common 3.3 V, which leads to a 20 % decrease in power consumption. It also allows us to maintain a stable supply voltage over the whole battery life time of a Lithium-Ion battery without using a switching voltage regulator. This is particularly important for the precise measurement of analog inputs like gyroscopes.

The CPU can run at variable clocking frequencies of up to 64 MHz without an external quartz. We measured its computational efficiency with the Dhrystone and the Whetstone benchmark as well as with the calculation of a FIR filter. We found the most efficient setting of the RatMote CPU for computationally demanding algorithms to be 48 MHz. At this setting, RatMote is able to compute *22 times* more FIR filter calculations per mAh and is 14 times faster than the widely known TelosB sensor node [4].

Despite a sleeping current of 380 µA our platform is still more efficient than a TelosB sensor node, if at least 1.1 FIR filters are calculated per second. A further reduction of the sleeping current is planned for the next revision of RatMote.

Aside from our project, we envision this new hardware to be useful in a wide range of other research questions, like medical applications, animal tracking, process management, and logistics. The improved processing power allows complex behavior analysis and classification routines.

IPSN'10, April 12–16, 2010, Stockholm, Sweden.
ACM 978-1-60558-955-8/10/04.

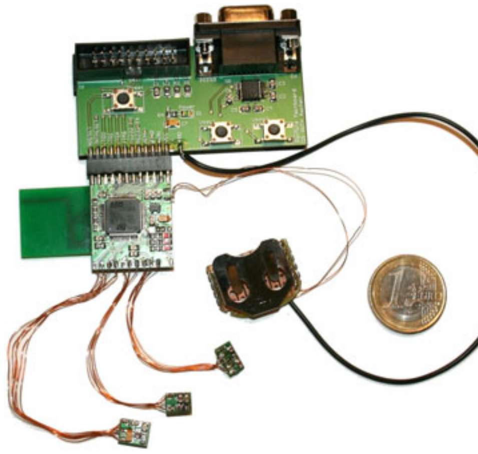

Figure 1: RatMote connected to a programming board for programming and debugging purposes. There are three different sensor extensions attached to it: A 3D accelerometer, a 3D magnetometer, and a 2D gyroscope.

3. DEMONSTRATION OVERVIEW

To demonstrate the feasibility of our hardware platform we present a demo setting that allows the audience to *play* with our new sensor node while demonstrating its capabilities.

The setup features a stuffed rat, which carries a RatMote on its back, just like actual rats in context of our RatPack project, which we are pursuing in cooperation with the Department of Cognitive Neuroscience at Tübingen University. The node will send its collected data via radio (IEEE 802.15.4) to a base station, where that data is then evaluated and displayed.

We then display the data in two different visualizations, a more technical representation of the measured data we dubbed the *RatMote Monitor*, and a maze based simulation game titled *PacRat*.

The *RatMote Monitor* (compare to Fig. 2) allows to view the collected sensor data in raw format and features a 3D rat aligned accordingly to the rotation of the stuffed rat the user moves and turns. Beside the visual representation, the actual numerical values can be displayed

PacRat closer resembles the anticipated usage of the sensor platform. This game features a 3D rat that is controlled by the movement of the stuffed rat. A gesture tilting the rat from left to right and thereby simulating a step motion results in the virtual rat moving forward. Turning the rat allows to control the movement direction. The rat moves trough a virtual maze (compare to Fig. 3), collecting sensor data as it makes its way all the way to the exit. Occasionally, it encounters computer-controlled virtual rats and exchanges data with those. The simulation also allows a rat to leave the track trough gaps in the wall or by jumping over the boundaries of the track.

In the context of the RatPack project [3] we demonstrated that we can generate a close reconstruction of a rat burrow based on sensor data collected by multiple rats [2]. This simulator allows to create realistic sensor data by moving the rat through the maze, allowing us to fine-tune the reconstruction algorithms.

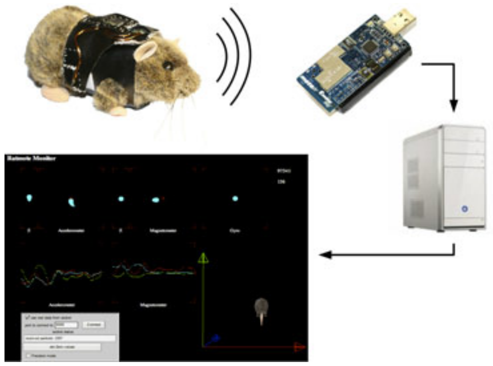

Figure 2: RatMote sends measurements via radio to a base station. A monitoring application then displays the data in several graphs.

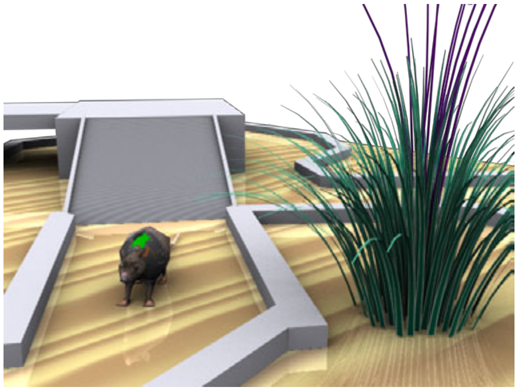

Figure 3: A virtual rat walks through a virtual maze. It collects data and meets other virtual animals.

Future work with respect to the simulation includes realistic animal behavior and mobility models. Rat behavior is driven by a variety of factors, including gender balance, dominance relationships, social composition and geographical factors. Accurate modelling and automatic detection of these can further enhance the usefulness of our system.

Acknowledgements

This work was partially supported by the DFG excellence intiative and the German National Academic Foundation.

4. REFERENCES

[1] ARM Limited. ARM Cortex-M3 Datasheet. http://www.arm.com/pdfs/Cortex_M3_DS.pdf, 06 2006.

[2] J. A. Bitsch Link, G. Fabritius, M. H. Alizai, and K. Wehrle. BurrowView - Seeing the world through the eyes of rats. In *Proc. of IEEE IQ2S 2010*, Mannheim, Germany, 2010.

[3] J. A. Bitsch Link, K. Wehrle, O. Osechas, and J. Thiele. Ratpack: Communication in a sparse dynamic network. In *SIGCOMM'08 Poster*, 2008.

[4] Crossbow Technology, Inc. TelosB Mote Datasheet. http://www.xbow.com/Products/Product_pdf_files/Wireless_pdf/TelosB_Datasheet.pdf, 2009.