A Domestic Adaptable Infant Monitoring System Using Wireless Sensor Networks

Hong Zhou, Brad Goold
Faculty of Health, Engineering and Science
The University of Southern Queensland
Toowoomba, Australia
Email: hzhou@usq.edu.au, w0085400@umail.usq.edu.au

Abstract— There are many accidents that occur in home every year, many of which are fatal and often involve with young children under the age of 4. Although many innovative applications using WSNs (wireless sensor networks) technology have been developed, little attention has been given for protecting children from potential harms and risks in the home environment. This paper reports our work on the design and implement of an Adaptable Infant Monitoring System (AIMS) using TelosB sensor motes. AIMS system is an open-source tracking and monitoring system with minimal cost, knowledge and time to set up. For performance comparison, three different localization algorithms are proposed and implemented in the system. Extensive tests under different scenarios demonstrated the working of the prototype system.

Keywords - wireless sensor networks, smart home, child tracking, health and safety, localization.

I. INTRODUCTION

There are increasing demands for improving the efficiency and productivity in health and child care domain. Health and child care cost taxpayers significant amount of money every year and we will see the expenditure in these areas continue to climb. Statistics also shows that there are many accidents happened at home every year, many of which involve children [1]. The Royal Life Saving National Drowning Report stated that 19 children under 5 drowned in swimming pools alone in the 2012/13 financial year. In addition, 4 more children died from drowning in spas in the same period of time [2]. In all children's accidents, about 39% are from falling; another larger proportion of accidents are caused in lounge and living area with most of serious accidents caused in kitchen area because of burns; 3% toddlers die by drowning in the bath or swimming pool.

Wireless Sensor Networks (WSNs) pose as the most important enabling technology to achieve ubiquitous computing in the next decade. The prospects of deploying WSN in child and health care environments have inspired many innovative ideas and generated many initiatives [4][5][6]. Despite the strong growth of WSN market, the current childcare products are costly and lack of localizability and adaptability [3]. This research aims to design and implement an out-of-the-box solution for personnel localisation at homes or residential buildings. It was focused on delivering a simple and cost-effective solution whereby the user requires minimal set-up time and technical knowledge in order to successfully interact with the WSN at home.

Monitoring and tracking an object or personnel indoor has attracted significant amount of attention over the last decades. The research developed in this area generally can be classified into two categories, range-free and range-based algorithm. Range based localisation is where the target node's position is found by using range measurements such as received signal strength, angle, time, or phase to position the target node. Using RSSI (Received Signal Strength Indicator) as the location parameter is one of the most widely researched topics in regards to (indoor) localisation [7][8]. A typical range-free technique is fingerprinting [9]. A number of algorithms such as MMSE (Minimum Mean Square Error) [10] or KNN (k Nearest Neighbour) [11] have been proposed to localised the node using this technique.

II. AIMS SYSTEM DESIGN AND IMPLEMENTATION

TelosB motes have been selected for the design and implementation. Fig. 1 gives an overview of the major system components.

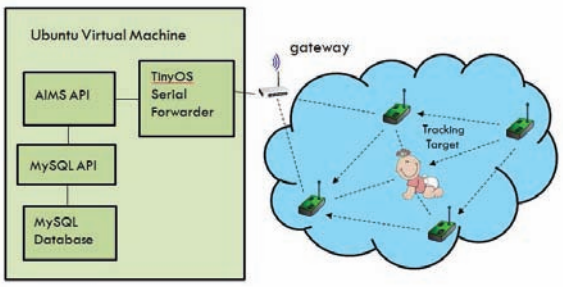

Figure 1. System Architecture

AIMS system incorporates the software developed for the TelosB motes in conjunction with the software that resides on the central computer for localisation, storage and remote retrieval. The current AIMS system produces a basic text-only user interface. To increase the accuracy of the MMSE algorithm, two algorithms, Centroid algorithm and

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Weighted Centroid algorithm are proposed and implemented in the system.

III. System Evaluation

To ensure the system performs as expected, a series of tests under different scenarios and with different algorithms had been carried out. Average accuracy and response time are identified as the two major metrics. Detailed tests on accuracy and response time can be found in [3].

A. Test Design

Different scenarios are considered aiming to provide performance comparisons of different algorithms and domestic environments. A photo for baseline testings is given in Fig. 2. Test procedures for all scenarios were developed and followed. Besides the tests above, boundary test procedure to trigger the alarms whenever the target moves out of the boundary were also designed and implemented.

Figure 2. Testing the sterile area with LoS for all positions

B. Testing Results

Comparisons of different scenarios and algorithms can be observed from Fig. 3. The localizations under residential scenarios were slightly more accurate than those with baseline tests. Based on the results, the best performing algorithm was the Centroid algorithm at 4 vertices. This equates to the centroid of a polygon of the 4 best database matches.

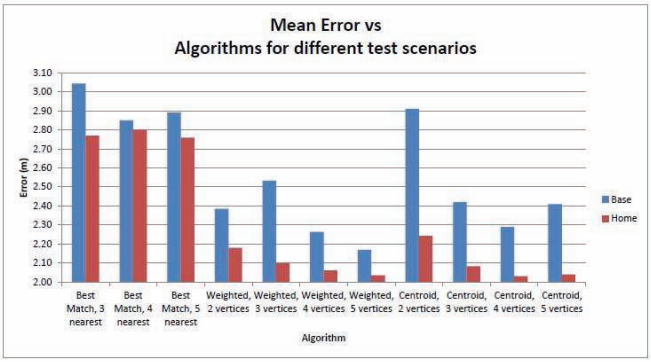

Figure 3. Mean Error vs Algorithms for Home and Baseline tests

The boundary and alert test results showed the successful transitions among states when the target moves among safe, transitional to unsafe zone. The transition of state in the software can trigger a variety of different alarm mechanisms, for example, a digital alarming sound output at home, or an email or a text message to a mobile.

IV. Summary and Conclusions

This research investigated the viability of using a wireless sensor network for a child safety protection application. A prototype AIMS system with both localization and boundary alarming functions was designed and developed in a typical domestic environment. Although the primary purpose of this study directed to prevent children from injuries or death at home, the system can be extended for many other applications such as tracking elderly people (e.g. Alzheimer's patients) in a similar environment.

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