Real-Time Constraints for Activities of Daily Living Recognition

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ABSTRACT

In this paper, we presents real-time constraints we have to face while building a system to recognize activities of daily living in a smart home using Radio Frequency IDentification (RFID) tag. We also present how we addressed them.

CCS Concepts

•**Applied computing → Life and medical sciences; Health informatics;**

Keywords

Smart home, Real-Time, Tracking, RFID, Decision Trees

1. INTRODUCTION

In recent years, we assisted a growing interest in smart homes as a way to allow elder to age in place [5]. Houses equipped with a large range of sensors are seen as a way to reduce the pressure on healthcare systems by delaying institutionalisation [3].

Smart homes rely on many technologies for different tasks. Motion detectors can be used to turn lights on while heat detectors can be used to monitor an oven surface [4]. One common task is to recognise activities performed in the home. Activity recognition can be achieve in many different ways. A common way is to use non intrusive technologies like wi-fi or Radio Frequency IDentification (RFID) signals by placing tags then try to infer activities by tracking the tags [2].

We chose to use RFID over wi-fi or other similar technologies because passive RFID tags are cheap and have a very long lifespan. They are also very small and resistant enough to be placed on almost everything [1].

This paper presents IPADL (Indoor Positioning for Activities of Daily Living), the system we built to perform activity recognition using RFID. We first describe the overall system before moving to the real-time constraints IPADL faces.

2. SYSTEM DESCRIPTION

In this section, we give a short description of IPADL and its components. IPADL is a near full stack solution that converts RFID readings to recognised activities. Data acquisition from the antennas is done by an automaton that collects all data from the smart home (not only RFID) and places it in a database.

There are many modules in IPADL, each one specialised to do one specific task. Figure 1. shows a global overview IPADL. Modules are represented by rectangles. They evolve in different threads. They communicate by exchanging messages of predetermined types, the parallelograms in Figure 1. Messages are handled by a publish/subscribe *Message Broker* shared between modules. The module *Acquisition* takes RFID readings from the database and converts them into a vector containing the readings from each antenna for a given tag. This vector is sent to some stabilising filters in *PreProcessingFilter*. Then, the *Positioning* module converts the vector into an actual position in the smart home. More stabilising filters are applied in *PostProcessingFilter* before the filtered positions can be used by the *ADL* module. This final module infers activities probabilities and returns them as a table. The *UI* module shows objects' positions within the smart home and the activity probability tables.

3. REAL-TIME CONSTRAINTS

IPADL is designed to provide real-time activity recognition inside a smart home. This section presents the real-time constraints we face when building such a system. We can set the RFID antennas to emit at any frequency. This frequency must be chosen wisely as it must be high enough to allow many readings per second but low enough to allow IPADL to keep up. Therefore, the delay between two RFID readings is also the maximal time each module has to do

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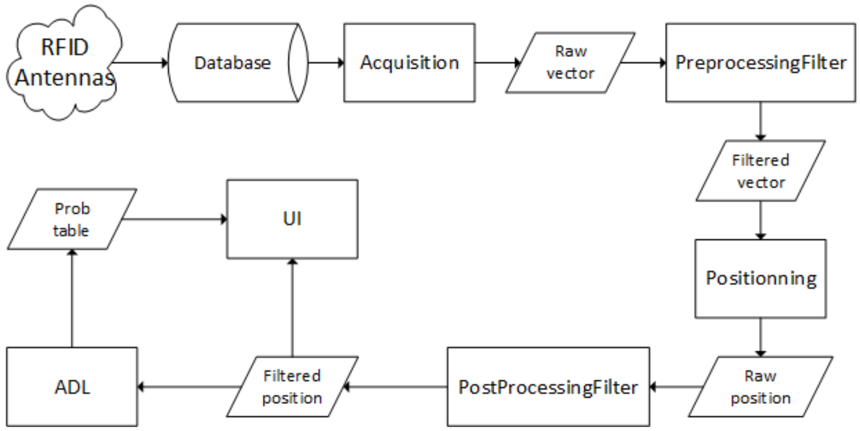

Figure 1: Global overview of IPADL. Rectangles are modules running on their own thread and parallelograms are the messages exchanged by modules.

its task. This time limit must be strictly measured in each module. The next subsections present how.

3.1 Data Acquisition

The first real-time constraint in the IPADL pipeline is in the acquisition module. We want raw inputs to be injected in the system at the pace they are produced. The effective method to fetch data from the database is to retrieve all relevant information in a single SQL request. This way, we can add more RFID tags in the smart home without significantly increasing the time spent in this module. Still, time spent must be tracked so appropriate actions can be taken if the system begins to fall behind.

The algorithm we use to measure time in this module is straightforward. The first step is to save time at the beginning. Then, after the SQL request and the treatment of the answer, we save the final time and compute the time elapsed. If the time elapsed is greater than the allocated time, then we notify a global time manager who will take required actions. Lastly, we put the thread to sleep for the remaining time before the next data is produced.

The time manager can act differently given the situation. Experience shows us that the first request to the database takes about 150ms while subsequent requests take about 3ms. Given a frequency of 50Hz, 150ms is too slow but 3ms is good. In this precise situation, the time manager does not act at all. In another situation where the module would take too much time to execute several times in a row, the time manager would notify the user that something is wrong and decrement the frequency of the antennas and the acquisition module by a small amount, such as allowing five more milliseconds between readings. The time manager will make sure IPADL is always fast enough to follow the antennas, but it is the human supervisor's job to make sure the frequency is high enough to be useful.

3.2 Constraints on Other Modules

In addition to the main constraints, IPADL faces other secondary temporal constraints. The acquisition module works by fetching data once every given time matching data production speed. The others modules do not have this limitation and can execute themselves in a more reactive way by consuming received messages as they arrive. Still, each module must do its task in the given time and notify the time manager when they fail to do so. Positioning and ADL modules are the slowest and their tasks must be kept simple or use fast algorithms. The pipeline structure of IPADL assures that there is at most five cycles between the RFID reading and the activity probability table. At a frequency of 50Hz, this means at most 100ms.

4. CONCLUSION

In this paper, we presented IPADL, a system that recognises activities of daily living using passive RFID tags. More focus was put on the real-time aspects of this system. In the near future, it would be interesting to allow the time manager to also decide when the system is too slow to provide useful activity recognition and to allow it to act accordingly.

5. ACKNOWLEDGEMENT

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