Project Progress

Aleksandar Krastev (s0833784)

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1 June 16, Sunday

- Downloaded Raspbian Linux. It is a flavour of Debian Linux that is optimised for the Raspberry Pi. Its packets are compiled to use hard floating point arithmetic because the Raspberry Pi does not have floating point hardware to bring costs down. The operating system's image was downloaded from `http://www.raspberrypi.org/downloads`.
- Followed instruction at `http://elinux.org/RPi_Easy_SD_Card_Setup#Using_the_Linux_command_line` to install an operating system on the 3 SD cards.

2 June 17, Monday

- Tested the 3 Raspberry Pi that their operating systems booted and ran as expected. Updated the systems and expanded the SD card partitions to fill the entire space on the SD cards (3.9Gb). Renamed the hostnames of the devices pi0, pi1, pi2. Marked the devices and SD cards with numbers 0, 1, and 2.
- Connected the 3 devices to a switch (given to me by my flatmate). Then connected the switch to the our flat's broadband ADSL router. I reserved the following IP addresses for the devices - 192.168.1.10, 192.168.1.11, 192.168.1.12 - using the RasPi's MAC addresses for identification. The devices successfully connected to the router and were assigned their reserved IP addresses. They could ping websites (internet connection) and could ping each other (local connectivity).
- Installed a web server (apache2), PHP (php5), and an SQL database (sqlite3) on pi2. The web server was running successfully and could be assessed through the LAN (Local Area Network).

- The idea is to code in Python to store data in a sqlite database that could be accessed by PHP to display data on the website that could be accessed remotely. Further plans include setting parameters through the website so that they could affect the remote system. Have to think about (explicit) transactions in the database so that both sides of the system can read/write without race conditions or data corruption, i.e. need to find means for synchronisation.

- Wrote a small PHP script that could be found at `192.168.1.12/status2.php` on the LAN and runs on pi2. The script does checks if the a SSH socket (number 22) can be opened on all three devices and displays if the devices are ON or OFF at the web page.

```php
<?php
$pis = array(
		'192.168.1.10',
		'192.168.1.11',
		'192.168.1.12'
);
$data = '<html><body>';
for ($i = 0; $i < count($pis); $i++) {
		$sock = @fsockopen($pis[$i], 22, $errno, $errstr, 1);
		if ($sock) {
				$data .= '<p>pi'.$i.': ON</p>';
				fclose($sock);
		} else {
				$data .= '<p>pi'.$i.': OFF</p>';
		}
}
$data .= '</body></html>';
echo $data;
?>
```

- Created an image of the current configuration of the pi2 (working OS with web server) so that if something goes wrong the system can be restored fast. Compressed the image (using xz) so that it takes less space.

- Applied for a free Student Micro Account (5 private repositories) on GitHub. My account was upgraded and I created a private repository for my project at `https://github.com/sandio/raspi-rfid-tracking` (not accessible because it is a private repository). If Michael Rovatsos or Michael Anslow have profiles at GitHub can add them as collaborators. This repository will be used by me to record any progress made as well as to write my thesis. I think it is a good place because I can record different versions of my work. The repository will be used by the RasPis also. It will contain the source code of the project. Any changes will be documented and committed to the GitHub server so that all devices and collaborators have the most recent version of the project. I plan to tag a bundle of source code changes into versions (eg. v0.1) so that the project progresses through versions with added functionality or fixed bugs. I plan to use GitHub's issue tracker in order to record bugs and my feature requests.

3 June 18, Tuesday

- Created this project progress document.
- Came up with an idea that all devices can run the same setup. More specifically, each device will get data from its neighbours and compute a possible position. After 3 positions are computed independently one RasPi can act as an arbiter to decide which is the most probable position. This idea can be applied once one device can compute the tag's position based on the distance readings of the 3 RasPis.
- Read and highlighted "An Introduction to RFID Technology" by Roy Want [Want, 2006]. It is good introductory article that clearly explains different classifications of RFID. It has helpful graphics for the distinction between near and far field RFID communication.

4 June 19, Wednesday

- Read and highlighted "RFID Tags: Positioning Principles and Localization Techniques" by Mathieu Bouet [Bouet and dos Santos, 2008]. Contains similar introduction to RFID technology. Explains the role of the server (RasPi in our case) connected to the readers that runs a localisation algorithm and provides the middleware for communication between servers. Contains a good classification of indoor localisation algorithms - distance estimation, scene analysis, and proximity. A brief but clear explanation of lateration with a useful figure. Contains a classification of range measurements techniques starting with Received Signal Strength (RSS) that will be used in this project. "The attenuation (gradual loss) of emitted signal strength is a function of the distance between the emitter and the receiver."

A classification of different RFID localisation schemes is proposed. The first one is SpotON where multiple readers collect RSS measurements in order to approximate distance from the tag. Then lateration is performed to localise the tag.

Landmarc is another approach that uses reference tags that are regularly deployed on the covered area. The idea here is to select the k nearest reference tags that are closest to the unknown tag using differences in RSS measurements. Having identified the k nearest reference tags their coordinates are used to localise the unknown tag.

VIRE extends the methods used in Landmarc by defining a proximity map that every reader records. This proximity map consists of a 2D grid of reference tags where the centre of a cell is a tag. The difference in the RSS measurements between reference and unknown tag helps label cells in the proximity map so that it can be constructed. The union of individual proximity maps gives a global proximity map for the unknown tag.

Simplex is a method that requires different transmission power levels. I am not sure if our equipment has this feature.

A Kalman filtering method is briefly explained but have to read the original paper because it is hard to understand from a one paragraph description of the method.

Scout is a probabilistic localisation technique that uses a probabilistic RSS model to estimate distances from a tag to readers. Predicted beliefs are calculated and corrected using reference tags until a good model is constructed.

- Read and highlighted "Semantic Sensor Net: An Extensible Framework" by Lionel Ni [Ni et al., 2005]. It is more concerned with sensor networks with multiple nodes, where the nodes have less importance than traditional computer networks. The article proposes an extensible framework for sensor networks that relies on attaching semantics (meanings) to sensor data but also to sensor nodes, location, context, and queries. The idea is to attach a meaning to every piece of information so that those meanings can be used by the network to route and aggregate data more efficiently, for example. This paper does not have a direct connection to this project but gives grounds for thoughts about attaching meaning to measurements, considering heterogeneous RFID reader nodes, and taking scalability into account.

- Read and highlighted "SpotON: An Indoor 3D Location Sensing Technology Based on RF Signal Strength" [Hightower et al., 2000]. It is a fine-grained tagging technology for 3D location sensing using radio signal strength analysis. They tried to develop a low cost system compared to commercial solutions available at their time. They believe that the accuracy and efficiency of location sensing could be enhanced by sensor fusion, i.e. adding more sensors (accelerometers) and building maps. These authors talk about ubiquitous computing. They try to separate the meanings of positioning and tracking. Positioning is concerned with providing means to calculate location which can be used to compute an actual position. Tracking is monitoring objects without involving them in the computation. They define location sensing to be such systems that separate the manipulation of location data from the mechanisms of actually pinpointing the objects. They used radio devices with a serial connection similar to the devices that will be used in this project. They were talking about the limitations of such a serial connection (R232) which will mitigated in our case by using a converter from serial to USB. In our case base stations that aggregate information and a server that processes it is combined into the Raspberry Pi computer.

This paper summarises the localisation algorithm they used based on the conversion of distance into signal strength in 6 directions in 3D. Then the measured RSS is compared to the 6 known RSS to find a location around a reader. They do not store data or timing information on the server, which I am planning to do. They have a visualisation client written in OpenGL.

Their results are not very accurate because they use radio devices with 2-bit RSS accuracy compared to modern onces with 8-bit accuracy. Their second problem was measurement frequency which happened between 10 to 20 seconds, which is too slow to monitor real-time position changes of objects. They identified these limitations and solved them by creating a custom hardware.

References

[Bouet and dos Santos, 2008] Bouet, M. and dos Santos, A. L. (2008). RFID tags: Positioning principles and localization techniques. In *Wireless Days, 2008. WD'08. 1st IFIP*, pages 1–5. IEEE.

[Hightower et al., 2000] Hightower, J., Want, R., and Borriello, G. (2000). SpotON: An indoor 3D location sensing technology based on RF signal strength. *UW CSE 00-02-02, University of Washington, Department of Computer Science and Engineering, Seattle, WA*, 1.

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