Localization of Missing Entities using Parked Cars

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***Abstract*—We introduce a novel application to detect tagged entities using a platform based on parked cars. We show experimental results based on real data from the city of Dublin.**

I. Introduction

In the context of the Internet of Things, the vehicles that we drive are consistently becoming more connected to each other, to the infrastructure, and to the Internet [1], while their on board sensor complements and computing powers increase. This means that parked vehicles need no longer be sitting idle, providing no service to us, during extended rest periods when they are not being driven. Instead, we can now take advantage of them for services besides transport given that they can be considered as objects in the Internet of Things.

Particularly, we might consider the network of parked cars as a service delivery platform [2] that hosts a whole range of applications, from gas detection, to the application that is presently considered in this short note. Namely, we want to utilise vehicles that are parked for extended periods of time in dense, urban areas to detect and track moving, missing objects using RFID technology. Such entities might consist of a missing patient with dementia, a lost pet, or a stolen vehicle.

What makes a network of parked cars a suitable choice for such a task is, first, the sheer number of vehicles that are owned by people and the fact that, for 96% of the time on average, these vehicles are parked[3]. In other words, the network is vast. The network also does not require dedicated maintenance, and technology upgrades are easy [4]. Moreover, energy infrastructure and planning permissions are not required to establish the network.

The remainder of this note is as follows. The application of locating a moving, missing object is introduced in §II. Some preliminary experimental results are presented in §III and §IV concludes the note and provides indications of future work.

II. Proposed System

In this note, we aim to give a preliminary evaluation of the potential of using parked cars to provide the service of locating moving, missing objects, pets or people. In particular, we consider the example of a person in need of aid wearing an RFID tag. We aim to analyse the resource requirements in terms of car availability for providing the service and the expected time to locate the missing person. For this purpose, we consider realistic parking data from the city of Dublin (Ireland) in order to perform some demonstrative simulations of the proposed system, collect and analyse the statistics.

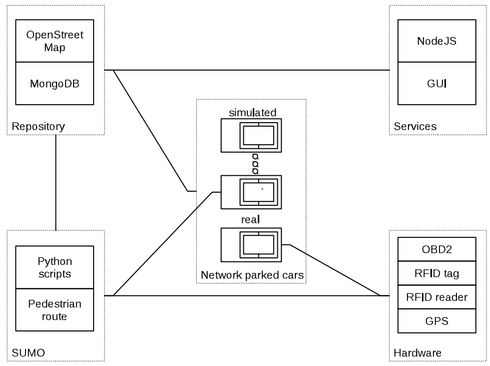

Fig. 1: High level system architecture

There are several groups of people in need that require special care and are at risk of getting lost. These include patients with dementia; children with severe cases of autism; individuals with attention deficit disorder, schizophrenia, severe clinical depression and brain injury; and individuals that are bound to wheel-chairs. Nearly 40 million Americans are over the age of 65 and 1 in 10 of them has Alzheimers disease. On average, one Alzheimer patient dies in Ireland per year because of the inability to locate them.

A high level architecture of our demonstration setup is provided in Fig. 1. To simulate a large number of parked vehicles participating in the localisation of a person, we utilise SUMO (Simulation of Urban MObility), a large-scale traffic simulator, which has incorporated into it the parking data from the city of Dublin. We also use SUMO to generate randomised pedestrian routes. Proof-of-concept of the system is provided by our setup in the form of an ability to embed into it a real vehicle equipped with an RFID antenna and its GPS location, and to demonstrate said vehicle participating in the search, as well as the sending of localisation events to a webserver (see Fig. 1). Statistics relating to the search time spent by each car as well as the time it takes to find a missing person are provided based on various scenarios.

A. Simulator

SUMO simulator is adopted to emulate scale in order to test the algorithms and the analytics using a realistic number of parked cars, and it is also responsible for generating a random path or the presumably lost object/person travels. The real car is equipped with a reader which detects tags at a distance. The lost object/person is assumed to have a RFID tag. The main advantage of using this technology over Bluetooth is

```
1:  procedure EnergyManagement
2:      t ← 0; r ← RANGE; n ← NEIGHBOURS
3:      cars ← getParkedCars(t)
4:      for all car in cars do
5:          if rand(0, 1) ≤ 0.5 then sensor ← ON end if
6:      end for
7:      while TRUE do
8:          t ← t + 1
9:          cars ← getParkedCars(t)
10:         for all car in cars do
11:             neighbours ← getNeighbours(car, r, cars)
12:             if neighbours.size ≤ n then
13:                 sensor ← ON
14:             end if
15:         end for
16:     end while
17: end procedure
```

Fig. 2: Energy Management Algorithm

that the RFID tag is passive and does not require an energy source, which is typically a limiting factor considering the inconvenience of battery charging, the size, and the limited life if an object is lost for a prolonged time. Thus, the energy requirements are unloaded to the cars which are expected to have a large battery capacity, especially considering the increasing and more widespread use of electric vehicles.

B. Energy management algorithm

In order to limit the energy consumption for the cars' batteries, an energy management system has been implemented. Particularly, not all cars need to be actively searching together and thus an algorithm that controls the activity is described in Fig. 2. In the first phase (lines 3-6), the algorithm initializes the car status randomly, while in the iterative loop (lines 7-16), it sets the car status according to the following rule: reader is ON if the number of the active neighbours in a range r is lower then a threshold n ($getNeighbours$ returns only the cars in a range r with the sensor switched ON).

III. Results

In the city center of Dublin (*yellow* area), smart parking meters record each transaction; City Council provided us with data that includes 363 smart parking meters managing 7443 spots within 215 streets. This data is a subset of the available parking spaces since it does not include the *non-smart* meters, residential and illegal parking. We ran the tests using this dataset which may be considered as a worst-case scenario since in reality more parked cars are available. We assume also that only 20% of the parked cars contain the required hardware for the tag detection and for the network communication, and are thus participating in the proposed system.

Table I shows the percentage of time that the car reader placed at Marrion Square East Road (Dublin) is switched on as a result of applying the energy management algorithm described above. $RANGE$ and $NEIGHBOURS$ are the two parameters used in the algorithm, the values of $RANGE$ are chosen based on a typical range for RFID and Bluetooth technologies. The results show that the percentage is inversely proportional to the number of active $NEIGHBOURS$ and to the reader $RANGE$. For example, for a 5 meters range which is a typical value for RFID communication, and with a threshold of 1 active neighbour, the car reader is switched on for half of the time (54%), while for Bluetooth technology with 30 meters range and a threshold of 3 active neighbours, the car reader is active only for 15% of the time. These statistics show how this simple energy management system will be useful in order to govern efficiently a fleet of cars, allowing to do not waste energy keeping the batteries active all the time while the localization and tracking service is active.

TABLE I: Car Reader Activity

		NEIGHBOURS		
		1	3	5
RANGE	5	54%	100%	100%
	15	14%	70%	100%
	30	7%	15%	67%
	60	3%	11%	18%

The results that are displayed in Table II show the amount of time that it took to locate a missing object in five distinct scenarios, simulated within SUMO, assuming $RANGE = 5$ and $NEIGHBOURS = 1$ at different times of the day (low, peek and standard parking occupation). Interestingly, on a weekday in Dublin city center it is possible to detect a missing moving entity in a few minutes on average.

TABLE II: Time to Detect a Pedestrian (in seconds)

	x_1	x_2	x_3	x_4	x_5	$\overline{x}$	σ
9am	386	554	730	1559	811	808.0	403.2
12pm	20	120	89	75	19	64.6	39.6
16pm	338	144	135	721	540	375.6	227.7

IV. Conclusion

The system proposed in this paper has several advantages. First of all, in urban environments, parked cars are ubiquitous and thus no additional infrastructure roll-out is necessary. Furthermore, by using RFID technology, battery powered tags are not needed. The system thus guarantees instantaneous coverage of a large area, exceeding the coverage provided by other state-of-the-art systems. Preliminary tests show promising results, and in particular, they show that a parked cars platform can be useful in solving issues such as the localization and tracking of missing entities. Future work will be focused mainly on integrating additional real cars in order to better assess the operation of the system.

References

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