Poster Abstract: Combining LoRa and RTK to Achieve a High Precision Self-Sustaining Geo-Localization System

Conference Paper · April 2018

DOI: 10.1109/IPSN.2018.00043

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Poster Abstract: Combining LoRa and RTK to Achieve a High Precision Self-Sustaining Geo-localization System

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***Abstract— Abstract*—High precision Global Navigation Satellite System (GNSS) is a crucial feature for geo-localization to enhance future applications such as self-driving of vehicles. Real Time Kinematic (RTK) is a promising technology to achieve centimeter precision in GNSS, however it requires radio communication and to reduce power consumption this is done at meters range, reducing the use in navigation systems. In this work, we present a high precision low power systems that can be energetically autonomous. The proposed approach exploits a GNSS module with RTK combined with a long-range communication radio (LoRa) to achieve a high-precision localization system with minimal wireless radio infrastructure requirements. Wireless sensor nodes, designed to be energy efficient, comprise the system and they include a solar energy harvesting for self-sustainability. Preliminary experimental results, with in-field measurements, show an average accuracy below 1 meter up to more than 1km distance of the end-node from the geostationary reference anchor; with a peak accuracy of only 10cm. Low power consumption is also presented with in-filed measurements.**

Keywords—Localization, RTK, Low Power Sensor Node, Long Range communication, energy harvesting

I. INTRODUCTION

The Global Navigation Satellite System (GNSS) is a key technology in navigation devices. Today, position information is widely available, as almost every smart phone, car and other smart mobile device has a GNSS module on-board. GNSS positioning works by measuring distances to satellites, so called pseudo ranges. The positions/trajectories of the satellites are known from the GNSS and with triangulation algorithm it is possible to have the absolute position of the device. In GNSS a minimum of 4 pseudo-ranges to 4 different satellites are required [1]. The pseudo-range is obtained from the time difference of the satellite signal transmission and reception time. Although GNSS is quite popular, its precision is quite low with ranges of 2-3m, up to 10m. This precision is enough for vehicular navigation, however it insufficient for example high precision applications, such as in localization of trains in a railway network, where precision is necessary for control or applications such as autonomous train driving or collision avoidance systems [2].

A recent methods to improve the accuracy of the GNSS system is using differential GNSS (DGNSS), where an additional receiver is placed in the mobile device, to receive information to correctional data which helps to increase the accuracy of the localization[2]. Among others, Real-Time Kinematic (RTK) GNSS, is based on a base station module on a fixed precisely-known position, and an end-device called Rover that is mobile device. In RTK, the base station sends information that allows the Rover to improve its accuracy when it has at least five satellites in common with the base station [3]. DGSS with RTK techniques improves the precision up to centimeters range [3].

Usually GNSS systems for auto, trains and other vehicles are coupled with 3G/4G wireless interface that allows sending the position information to a remote host and tracking the mobile device. However, for precision data exchange needed for RTK DGNSS, 3G/4G is almost never used, due to the power consumption and the fact the interface requires a network operator so it is not possible to have a direct connection between rover and base station in an inexpensive way. Pushed by the big wave of Internet of Things, Long Range (LR) low-power wireless communication in the ISM narrow band (usually 868MHz) is enabling new types of services. LoRaWANN [4] appears to be particularly promising especially for the mW range power consumption. LoRa, owned by Semtech, allows transmissions over kilometer distances without the use of third party network operator. Due to long range and low power consumption, LoRa is becoming popular for many IoT applications [5].

Another issue with GNSS is they are quite power hungry to be supplied by Li-Ion batteries. This can be a critical issue for battery operated mobile devices that need to work for long periods. Although vehicular navigation systems can be supplied by the vehicle battery, in many application (e.g. trains or logistic containers) it is not possible to have access to the main power or the battery/power of vehicle for safety reasons. As a result, often train wagons or other containers with a GNSS system cannot be located and they get lost [2] [3]. Achieving a self-sustainable, giving position information is a critical target.

In this paper, *we present a high-precision DGNSS system that can be self-sustainable*. The system comprises sensor nodes that include LoRa communication, several sensors and a GNSS module. Every sensor node is designed to achieve low power consumption and extract energy from light exploiting a photovoltaic panel. The system exploits LoRa radio to both communicate the position to a remote host and to share information between base station and rover in RTK DGNSS mode. We implemented and tested the sensor nodes and the whole hardware/software system carrying out performance in terms of accuracy, precision and power consumption with in-field measurements. To the best of our knowledge, this is the first paper that combine LoRa with RTK showing high precision long range and low power consumption.

II. SYSTEM ARCHITECTURE.

Fig. 1 shows the high-level system architecture developed in this paper. The system comprises of three different types of nodes: a base station, a rover and a web gateway. All node types are an extension based on the WuLoRa sensor node presented in[5].

Fig. 1. Block diagram of the zero-power reciever for touch communiaction and touch sensors

Briefly, the WuLoRa is build around a MSP430FR5969 microcontroller and a LoRa Semtech SX-1276 radio module. The platform includes: a wake up radio to build energy efficient short-long range clusters; several MEMS sensors; and a solar energy harvesting subsystem. From an hardware point fo view, the extention consists in adding an RTK module, uBlox NEO-M8P-2, which is interfaced with the MSP430 via UART. Fig. 2 shows the block diagram of the new extention of the WuLoRa node.

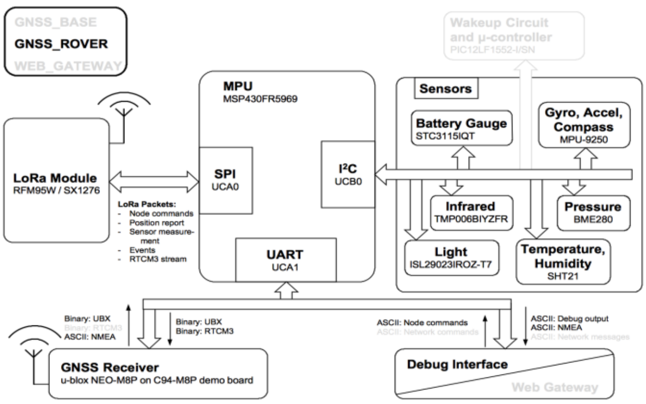

Fig. 2. Block diagram of the WuLoRa protoype with the Ublox module set as a GNSS_Rover.

III. EXPERIMENTAL RESULTS

The whole hardware and software system has been developed and tested in the field. In particular, we tested the system's functionality with respect to RTK accuracy/precision estimation and the power consumption. Fig. 3 shows an experimental sample where the user moved around 700m from the base station. Fig. 4 shows the accuracy achieved during the test phase estimated by the uBlox module itself. This figure shows many periods where the accuracy went below 20cm and this is independent from the range. In fact, for example this accuracy is achieved also when the use was more than 500m far from the base station (between x-axes 2250-2300). We tested also the power consumption of the whole RTK rover node, that results in 100μW of power consumed in idle mode where a timer is active for periodic wake-ups. On the other hand, the power consumption raises to 300mW when both RTK and LoRa radio are used. However, due to the low idle power and the solar energy harvesting, it is possible to achieve a self-sustainable system with a few cm^2 photovoltaic panel.

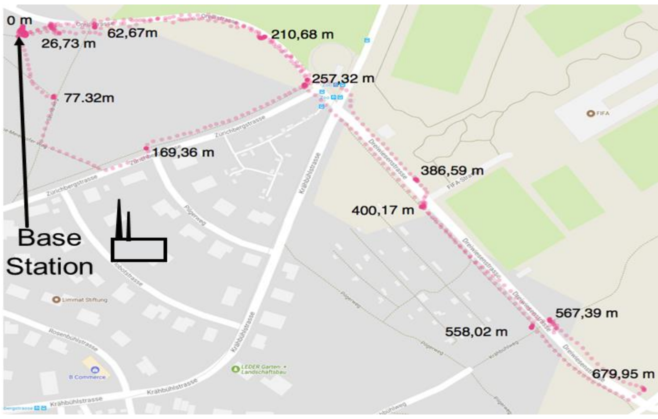

Fig. 3. Experimental measurement of the postion acquired by the rover and sent by the LoRa radio to the gateway.

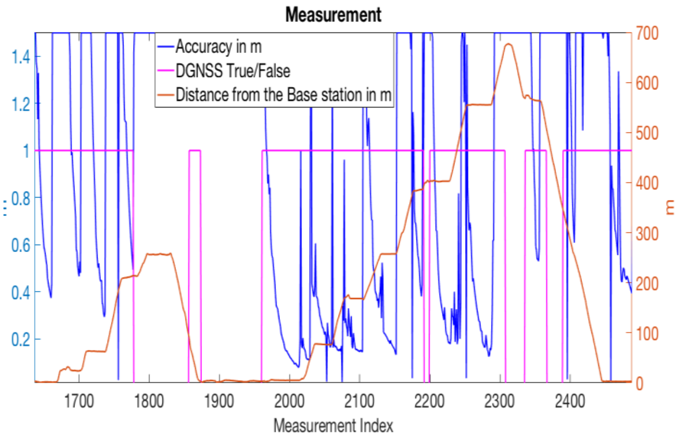

Fig. 4. Rover accuracy evaluation during the in-field measurements.

IV. CONCLUSIONS

This paper presented a high precision and low power system combining LoRa and RTK DGNSS. The mobile node is designed to be fully supplied by solar energy harvesting. The experimental results shows the benefits to use LoRa with RTK to exchange information between base station and rover to improve the precision up to centimeter range.

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