Visitor counting combining new technologies; PIR & LoRa with Arduino

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More research is needed to test the approach

The nature area 'Het Renkums Beekdal' in the Netherlands consists of a linear north-south valley with fringing forest on the hills to its East and West, with a modified, canalised watercourse that now runs in two separate streams on each side of what was once the flood plain (which is now a marshy wetland). The visitor centre lies on the edge of valley. The managers of the area are struggling to find an efficient way to keep track of both the number of visitors and their spatial distribution in the area. Previously they have tried to count the visitors manually by using volunteers, which yielded meaningful results but which was time and cost intensive. They don't have the financial resources to be able to use most of the currently available methods, so they therefore need new cost-effective technology that can count the visitors effectively and accurately. We therefore searched for open source methods and new techniques.

The Long Range (LoRa) network is a relatively new low cost technology that can be used to transmit accurate data from sensors. LoRa is one of the leading technologies that is used for building the Internet of Things (IoT) in a worldwide network. The industry claims a range of the LoRa gateway of 15 km. In this experiment, the open source The Things Network (TTN) was used as the network provider. According to the industry the benefit of this technique is that it combines long range, low power consumption and secure data transmission. Although the LoRa technique offers considerable potential, it also offers challenges. The research question is: 'What is the optimal means for applying the LoRa system to the task of counting the visitors in the Renkums Beekdal natural area, at the lowest possible cost?'

Method

A method has been developed for counting visitors by combining new technologies using Pyroelectric InfraRed (PIR) sensors together with so-called LoRa. The optimal way of using this new technique should be defined. First of all, sensor components had to be selected, which should be connected with the LoRa gateway. We installed the LoRa gateway on the roof of the visitor center in the valley. The Adafruit Feather M0 LoRa chipset was selected. The Adafruit Feather M0 LoRa, which is a Arduino based board includes a HopeRF96 LoRa enabled radio chip. Additional feathers are a micro USB connector and a plug for a Lithium Polymer battery, which can be charged from the USB. At a cost of 40 Euros the board is not only a complete package but also relatively cheap. The HC-SR501 PIR sensor also was selected as it is cheap, widely available, and allows for sensitivity tweaking on the sensor. As the sensors were placed in an outdoor environment, a waterproof and less vulnerable case also was created. To test the data management process in order to record and save the visitors data, several steps were taken. The Adafruit chipset was prepared by connecting it (by hand soldering) to the PIR sensor and the TTN network with a wire bridge and also connecting it with the antenna. Every complete package sensor was then registered in the TTN network console. The most important step was programming the Adafruit using open source Arduino IDE since it defined the data form from the sensor. The programming also included the selected spreading factor and the battery consumption. Finally, the LoRa gateway was adjusted in high sensitivity. To test the accuracy of the PIR sensors, we counted the amount

of visitors manually for two locations in the area on one day during the testing period in July 2017.
In order to visualize data interactively and to show data in a map format, the open source Grafana dashboard was selected, using open source InfluxDB as data storage. To keep data flowing, the open source node-red server was installed and was required to be running constantly on a computer in an online mode.

Results

From the original 15 locations spread around the natural area, only 3 sensors were operational because of a fault in the soldering. The Adafruits were able to connect over a distance of only 2.68 km from the LoRa gateway, because the amount of forest and hills in between sensor and gateway were limiting factors. The accuracy of the sensor was calculated for two locations. The average accuracy of sensor 1 was 60% and it increased to 83% when the false positives were removed. Sensor 2 had 62% average accuracy and it only had one false positive with no visitors crossing. The PIRs causes a considerable number of false positives due to wind. The effect is further amplified when the sun is shining.
Because the batteries had to be recharged after 10 days, the testing period was very short. An average amount of 64 visitors a day were counted in that period: when the 60% accuracy was applied to the original data, and when potential double-counting was taken into account (the same person can be counted by two sensors if they are close to each other). We couldn't give an answer to the spatial distribution of the visitors in the area, because we only had results of 3 sensors.
In the context of the disappointing results, the method with open source programs and the LoRa technique could not be considered optimal. However, the costs are low. Using open source programs the one-off cost of the method is € 3200,- including the purchase of a LoRa gateway, antenna and 15 sensor packages. In theory, the managers could have an overview of the number and distribution of the visitors using the open source programs; in reality it did not prove possible to install these programs on the their computer, but only on the computer of the student involved in this study.
The effectiveness of this approach could be improved adding a small solar panel to the sensor. It will increase the costs but also the battery life as the battery is automatically charged when enough solar power is generated. Purchasing a more accurate PIR sensor will also improve the results. Finally, in this experiment the forest and hills limited the range of the LoRa gateway. The range will probably be better if there is a clear line of sight between sensor and gateway.

Reference

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