Human Obstacle Independent Proximity Detection using Classification Techniques

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Proximity detection entails identifying with a high degree of probability the presence of a given person or object next to some reference location. It can be achieved by comparing the positions of the objects. Here we present a technique that is at the same time independent from any location system, is low-power and operates indoors. The experiments show that the technique is robust to the presence of obstacles.

Detecting the proximity between a person and a given location is at the heart of many applications. This can be the case in a restaurant, where clients would get the menu of the closest buffet displayed on their smartphones or tablets. Also it can be applied for security reasons, in a chemical plant for example, where workers receive an alert if they exceed the time allowed to stay near dangerous chemical products.

Proximity information can be inferred from the position of the parties. However this requires a global positioning system that is able to operate in-door. It is also possible to use the distance between the parties (ranging techniques) based on the time of flight (ToF) or the received signal strength (RSS) of the signal.

The choice of the proximity sensing technique depends on the required accuracy and system complexity. Many typical low power communication technologies, such as Bluetooth low energy (BLE) and radio frequency identification (RFID) have problems maintaining stable signal coverage and they are vulnerable to the presence of human bodies and metal objects nearby, as they can modify significantly the signal propagation patterns. This report presents the performances of a proximity detection system using machine learning techniques, and based on magnetic induction. Magnetic induction technologies have the advantage of being robust against shadowing and multipath in indoor environments, but they suffer from shorter transmitting range compared to RF technologies.

Rather than yielding a distance between the objects, the system classifies the distance as near, "in between" and far. The system is composed of a fixed transmitting and mobile receiving resonant circuits operating at 125 KHz. The transmitter holds three orthogonal coils that generate magnetic field lines in all directions in space. To avoid that the magnetic fields issued from different coils cancel each other, a de-multiplexer controlled by a microcontroller switches between the coils, allowing only a single coil transmitting at a given time. The receiver processor measures the received magnetic signal strength and makes the proximity decision. This is based on the mean and average values of 15 amplitude measurements from the coil yielding maximum power. These values constitute the feature vector of the classification method. The chosen classifier is a 3-way support vector machine (SVM), where the target classes are *white* (near), *grey* (in between) and *black* (far) zones. The 3-way SVM based classifier is obtained by combining two binary classifiers representing the *white/grey* boundary and the *black/grey* boundary (Figure 1). The system range is approximately 2.2 m.

To verify the robustness of the proximity detection, a total of 2100 feature vectors were acquired. Each one is calculated repeating 100 times the average and maximum values of 15 measured amplitudes every 10 cm. Measurement were performed from 10 to 210 cm. Half of these points were used to train the SVM-based classifier and the other half to test it.

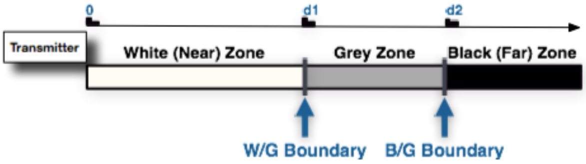

Figure 1: Detection zones.

In the test, the "near" zone corresponds to a distance smaller than 1 m from the transmitter, the "in-between" zone ranges from 1 to 1.2 m and the "far" zone is beyond 1.2 m.

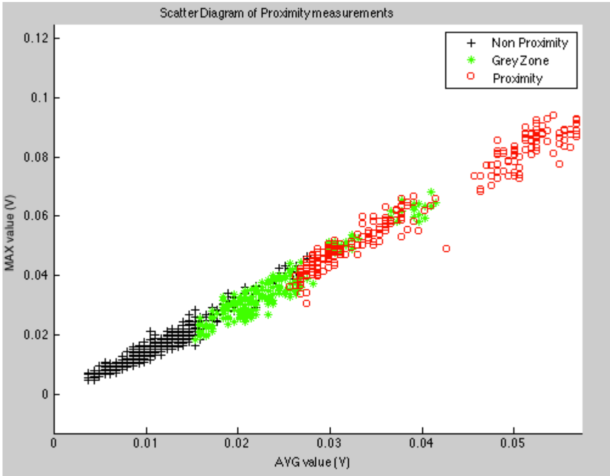

Figure 2: Scatter diagram of the measured feature vectors.

The distribution of these measurements is plotted in Figure 2. It shows that the grey zone is separable neither from the "far" nor the "near" one. In fact, the grey zone points overlap with the ones from "far" and "near" zones and so errors in classification are inevitable. However, the "far" zone points are linearly separable from the "near" ones and there should not be any misclassification between these two zones. 8% of the test points were misclassified but the important point is that none of the points in the "near" zone was misclassified into the "far" one or vice versa. Proximity detection thus achieved less than 20 cm uncertainty.

This solution is robust against non-magnetic obstacles thus human bodies hardly affect the received signal strength and the classification. It offers a robust alternative to systems like Apple iBeacon. The grey zone may be adjusted according to the application. Energy consumption on the mobile is kept to a minimum as the magnetic signal is used to wake-up the processor thus avoiding any waste.

This proximity detector may be combined with in-door positioning to improve the overall robustness of the solution.