Name(s)

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Project Number

S1203

Project Title

Combinatorial Design Criteria to Optimize Sensor Footprint Configurations (Year 3 of an Ongoing Study)

Abstract

Objectives/Goals

The effect of spacing between motion sensors on the number of detection zones will be determined by programming a computer simulation. Sensor spacing can be expressed as a fraction of the sensor footprint radius, r, thus providing a non-dimensional parameter that can be applied to any real sensor footprint size. The sensor spacing will be from 2r, resulting in n detection zones for n sensors, to a spacing less than 2r that provides the maximum number of detection zones, n(n-1)+1. The simulation will determine the range of sensor spacing less than 2r that provides this maximum number of detection zones. This project provides quantified guidelines for designing optimum configurations for large sensor fields.

Methods/Materials

The computer program implements the following:
1) Input the number of sensors, n, the footprint radius, and the radius of the reference circle on which the sensors are placed. 2) Calculate the maximum number of overlapping zones produced through the formula n(n-1)+1 for n sensors. 3) Equidistantly space the number of sensors around a reference circle by dividing 360 degrees by n, and use polar coordinate to rectangular coordinate calculations to determine the x and y values of each sensor location. 4) Calculate the sensor spacing using the mathematical distance formula between two points on a plane. 5) Create a display for the sensor footprint configuration. 6) Display the inputted values as well as the calculated spacing between sensors and the number of zones produced.

Results

Using this program, it was found that the original hypothesis that the maximum number of zones, n(n-1)+1 is achieved by a spacing, d, between a lower and upper bound fraction of the sensor footprint radius r, where the bounds may depend on the number of sensors, was found to be mathematically trivial in that the lower bound was always d=0 and the upper bound was always d=2r so that $0<d<2r$ always achieved the maximum number of zones.

Conclusions/Discussion

This discovery indicates that optimal sensor configuration should not be based on the number of detection zones but, instead, should be based on the usable area of each zone since sensor spacing within $0<d<2r$ can significantly alter the relative size of resulting zones. The computer program developed in this project is helpful in quickly plotting various configurations enabling the user to rapidly visualize and decide on a useful sensor configuration.

Summary Statement

This project continues the two previous ones to define the design criteria needed to optimize a sensor footprint configuration, thus reducing the number of motion sensors used to cover a given area and lowering the cost of security.

Help Received

Father guided me through topic selection and assisted me in the conceptual engineering background.