On Determining Optimal Range to Achieve Barrier Coverage with Directional Sensors

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1 Abstract

Directional sensors such as (orientable) lasers and (orientable) cameras are usually deployed for detection movements. However, despite an extensive investigation of the deployment issue for wireless sensor networks, there does not exist a theoretical foundation to understand the impact of orientability on the density or range needed to achieve a desired quality of coverage as compared to omnidirectional sensor, or non-orientable sensors. Also, it is not known how to determine optimal orientation for directional sensors.

In this work, we comprehensively answer these questions for the barrier coverage model. This model allows us to handle extreme directional sensors (i.e., lasers) that can not be used to provide full coverage. First, we derive reliable estimates of the range needed to achieve barrier coverage with non-orientable directional sensors in a random deployment. Second, we derive reliable estimates of density needed if the directional sensors are orientable. We show that the range needed for orientable lasers is asymptotically the same as the range needed by omnidirectional sensors, while the range needed by non-orientable directional sensors is at least π times that needed for omnidirectional sensors. We also provide an algorithm to determine orientations of sensors that ensures the range needed for orientable sensors is optimal for sector sizes of π or more and within a factor of 2 of the optimal, otherwise (including that for lasers). We expect our results to make a strong case for using orientable directional sensors for movement detection.