Summary

In-plane Object Detection: Detection Algorithms and Visibility Problems

A large number of devices today incorporate some form of detection of objects and people in a given environment. Various detection technologies have been developed over the years, as a response to many different demands. The devices such as video surveillance systems, scanners, touch screens and various systems for tracking people and objects in space, detect objects using camera videos and/or measurements gathered by sensors.

To enable simultaneous detection of multiple objects on table-top interactive devices designed to support games that combine the social attractiveness of traditional board games with the interactivity of computer games, an in-plane detection technology that uses LEDs and sensors was developed by Philips. The presence of objects on the table results in blocking light emitted by the LEDs for some of the sensors. This information can be used to determine the position and shape of objects such as game pieces or fingers on the table. If the detection process is performed fast enough, then moving objects can be tracked, for instance, to recognize gestures made by fingers. This detection technique gives rise to many interesting geometric problems, such as developing efficient detection algorithms. In addition, due to occlusion created by the multiple objects placed on the table, some visibility problems can occur in the process of detecting objects.

We present detection algorithms that use the sensor data as an input and provide an approximation on the geometry of objects as an output. We discuss the advantages and disadvantages of the presented algorithms and analyze their worst-case time complexity as a function of the number of LEDs and sensors.

In addition, the maximum level of the accuracy of detecting circular objects that can be achieved has been investigated. To investigate this maximum level of accuracy we assume infinitely many LEDs and sensors in a frame surrounding the

objects. We present and discuss a worst-case optimal algorithm that determines the output that a detection algorithm would provide in this case.

Several visibility problems have been explored that relate to occlusion, an intrinsic shortcoming of the detection technique. Among many visibility problems that can be identified, the focus was on five problems related to either falsely detecting a non-existing circular object or detecting multiple objects as one. These problems occur when multiple objects positioned in the detection area block all of the lines of sight between LEDs and sensors that cross some area that is not occupied by an object. In this thesis, we focused on exploring the worst-case scenarios, in other words, finding the minimum number of identical circular objects that can cause one such visibility problem to occur in relation to the distance between the objects. We have proved that this number is quadratic in the minimum mutual distance between the objects. This result can be used in practice, for example, to adapt the layout of game boards such that these visibility problems can be avoided.