

## Automatic occupancy analysis of sports arenas

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### Introduction

Over the last decades the demand for physical activities has been growing, which puts a high pressure on the sports arenas. From 1964 to 2007 the number of athletes has quadrupled with a steady increase (Pilgaard, 2009). Surveys also show that people are dropping the classic club sports in favour of more flexible sports (Brixen et al., 2010). This calls for a better and more optimal use of the existing sports arenas to keep up with this growing trend. In order to improve the utilisation of a sports arena, its existing use must be examined. This includes examining the number of users using the arena at the same time and the occupancy of the court. Administrators are especially interested in whether the arena is empty, used by a few people or full and the time for when the occupancy changes. The position of the users is also important as they might only use half a court, which means the other half could be rented out to another group. Manual registration of this is cumbersome and expensive and an automatic approach is therefore needed. For such a system to work in general it should be independent of the size of the court, lighting conditions and without any interaction with the users. This can be obtained with a camera. Detecting people with a camera raises some privacy issues though. The fear of being observed could keep some people out of the arenas. This work therefore proposes an automatic method to analyse the occupancy of a sports arena using thermal imaging. One of the advantages of thermal cameras is that persons cannot be identified, which is an important factor if the system is to be accepted by the users. On top of that, thermal cameras are invariant to lighting, changing backgrounds and colours, which make them more desirable for an automated application.

### Method

The activity at the court is measured by a thermal camera mounted on one of the walls around the arena. The camera detects the long waved infrared radiation emitted by all hot objects which generates a greyscale image that represents the temperature in the scene. Hot objects will be bright and cold objects will be dark. This makes it relatively easy to make software algorithms that automatically separate people from the colder background.

For each image the persons are counted and their positions on the court are found using a prior calibration. By summing over several images this gives the number of persons and their position for every 5 minute period, which can be used to analyse the use of the arena. The detailed technical description of the system can be found in (Gade et al., 2012).

### Results

Preliminary tests of the system have been conducted in collaboration with the local municipality in ten different sports arena, one week at each location. All arenas have 20x40 meters courts. During the full test period the system shows that it very precisely categorises activity level into zero, low or high activity. The average error in counting the number of people is 11.76 % during time with activity.

Comparing the observations during an average week to the booking schedule shows that 21.2% of the booked hours were not used while 23.4% were used by an average of two or fewer persons.

For all open hours (7 AM to 11 PM) the arenas were in average occupied by more than two people 51% of the time. The best occupancy rate for one week in a single arena was 64% and the worst occupancy rate for a single arena 39%.

The registration of the positions has been visually evaluated by comparing with manually annotated positions and shows great resemblance.

### Discussion

The results show that the arenas are only occupied half the time. Furthermore only half of the booked hours are made use of. These results are obtained with the rule, that if three or more people are observed, the arena is registered as occupied, even though the capacity is much higher. The municipality used these results as basis for a dialogue with the users and managers of the sports arenas. It was received positively by everyone and for some it was a real eye opener. Having this data suddenly makes it clear for everyone that there is a lot of unused capacity that could be distributed more properly.

Work is currently being done to further improve the precision of the detection software. Future work includes automatic methods for detection of activity type, activity level and user type.

### References

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