OCCUPANCY ANALYSIS OF SPORTS ARENAS USING THERMAL IMAGING

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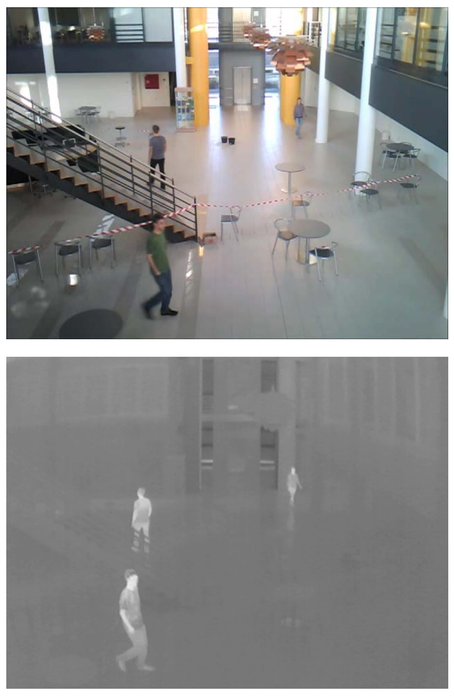
INTRODUCTION

The number of athletes is growing, putting a large pressure on the sports arenas. In order to meet the demand and improve the utilisation of the arenas its existing use must be examined.
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 use only part of the court, which means that the other part could be rented out to another group.
In this work we propose an automatic system that analyses the occupancy of a sports arena using a thermal camera.

Every object with a temperature above the absolute zero emits thermal radiation. The higher the temperature the higher the intensity. The main part of this radiation from objects at room temperature lies in the infrared spectrum from 7-15 μm. This is exploited by thermal cameras. The pictures can be represented as greyscale images with warm objects being bright and cold objects dark.



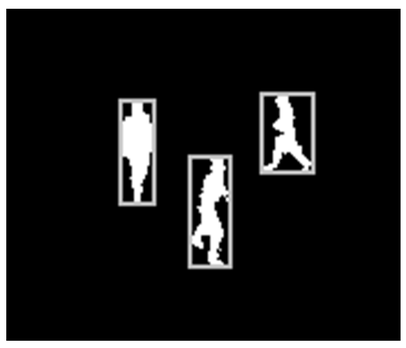
ABSTRACT

This work presents a system for automatic analysis of the occupancy of sports arenas. By using a thermal camera for image capturing the number of persons and their location on the court are found without violating any privacy issues. The images are binarised with an automatic threshold method and reflections and occlusions are dealt with through special designed algorithms. Tests in ten different arenas showed that the system can very precisely distinguish between zero, some or many persons at the court and give a good indication of which parts of the court that has been used.

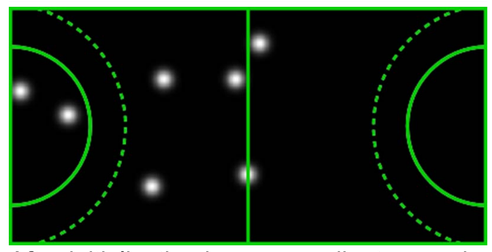
METHODS

The thermal images are first binarised using an automatic threshold algorithm, based on maximum entropy. Reflections due to shiny surfaces are eliminated by analysing symmetric patterns. Occlusions are dealt with through a concavity analysis of the binary region. The remaining white regions are sorted on their pixel size compared to their distance to the camera.

During an initialisation routine a mapping from image coordinates to world coordinates is calculated. This enables the possibility of drawing occupancy maps for the detected positions over.



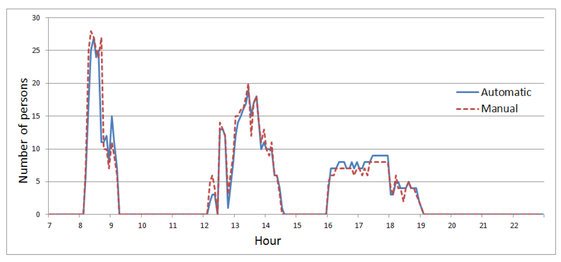
The desired system will take a thermal grey scale image as input and find every person in the image.
This example shows the ideal case where the persons are easily separated and no noise is visible. Each person is marked with a white bounding box.
In other cases the system must handle difficulties like occlusions, reflections and non-human warm or cold objects.



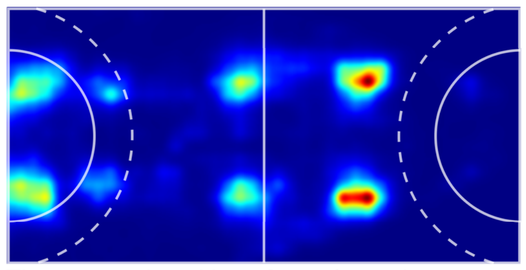
After initialisation image coordinates can be mapped to world coordinates using homography.

RESULTS

The system has been tested for one week in each of ten different arenas. The camera used is an Axis Q1921 thermal camera with resolution of 288×384 pixels and a horizontal field-of-view of 55°. The camera covers approx. 70-80% of the court areas. These tests proved that the system is stable over a long time period and that it is independent of the different environments. The ground truth has been found for two days by manually counting the number of persons in the video. It was found that the error was very low when detecting empty arenas, an average error of 0.17 %. With full activity on the court (7-15 persons) was the average error found to 11.76 %.



The number of persons during one day, compared to ground truth.



The summed position of people on the court during one hour of badminton.

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
7-8							
8-9							
9-10							
10-11							
11-12	School	School	School	School	School		
12-13							
13-14							
14-15							
15-16						Club	Club
16-17							
17-18							
18-19	Club	Club	Club	Club	Club		
19-20							
20-21							
21-22							
22-23							

Booking of an arena compared to the observed occupancy. Green: used, yellow: used for short time or by few people, red: not used, blue: used but not booked.

CONCLUSION

The proposed system shows very satisfactory results, with only a short initialisation it works independently of the changing conditions in different arenas. The system can easily distinguish between an empty arena, few or many people and give a good indication of which parts of the court that has been used.
The work will continue with further tests of the system and work on improving the segmentation of people. This could be by including temporal information or by using a more detailed human template for comparison with the found regions. For future work there are a lot of possibilities for developing new features, including analysis of the activity level, activity type and user type.