Thermal Infrared Localization

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I. INTRODUCTION

In contrast to outdoor localization where everything is based on GPS, there is no comparable system for indoor localization. Only a few expensive tag based systems like Ubisense [1] are available for purchase. Recent development in this field is mainly focused on radio based systems. Unfortunately, all radio based systems require some sort of tag to be attached to the localized object. This may be a solution for crates that are driven around warehouses but not for persons in home environments or assisted living residences. With the goal to provide supervision or assistance for activities of daily living, a system is preferred that does not need a tag.

Thermal Infrared Localization (ThILo) is an indoor positioning system that exploits the natural thermal radiation of humans. The detection is solely passive and easy to integrate in existing environments, due to the small sensor size. Furthermore, only eight sensor nodes are needed to cover a room of up to three persons. The nodes are placed in each room corner, which allows a full coverage of the room from each sensor node. The combination of the sensor measurements makes it possible to calculate the position of up to three heat sources within the room. Thereby, the low resolution of the sensor nodes does not allow any identification of a heat source and thus, the ThILo system provides full anonymity of the localized person [2]. An example of the sensor setup is presented in figure 1.

In contrast to localization systems based on radio frequencies, ThILo is not influenced by other applications that use the same frequencies. The only external influence on the localization accuracy is the ambient temperature, which can be neglected, since indoor environments are usually kept at an ambient temperature comfortable for humans.

Another advantage of ThILo is the low cost of its sensor nodes. Even in the prototype stage, a sensor node only costs approx. 50€, which leads to a price of 400€ for a one room setup. Also, due to its automatic calibration process there are almost no additional setup coasts.

There are still some challenges that have to be faced ThILo can be developed to a consumer ready product. One of them is the suppression of false detections that arise from warm objects within the surveillance region. These are typically devices like TV screens or heaters.

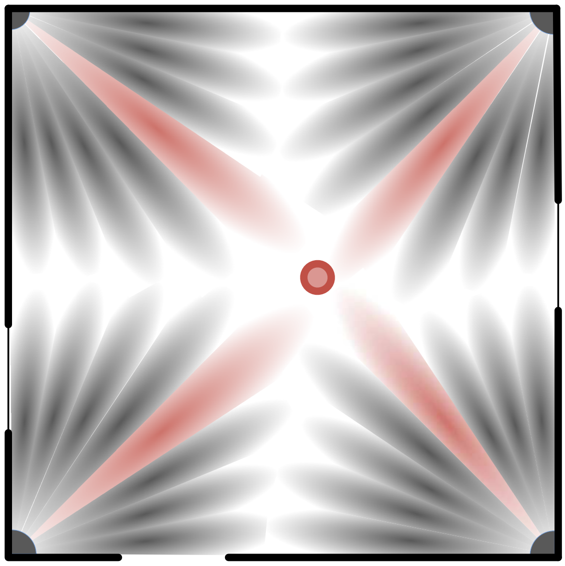

Figure 1 – ThILo sensor placement.

II. CONTEXT

The ThILo system is targeted to be used in context of Ambient Assisted Living (AAL). The provided anonymity and the passive approach are beneficial for the consumer acceptance in this field. Without the need to wear a tag that can be forgotten or misplaced, ThILo might provide an input for activity monitoring systems, which are in turn able to detect emergency situations.

Besides the position information provided by ThILo, current research also focuses on fall detection by using additional sensor nodes that are placed at different heights. Furthermore, new sensor nodes that provide a more detailed resolution are tested for this application.

III. TECHNICAL DETAILS

ThILo is based on the fact that every object with a temperature above absolute zero emits energy via electromagnetic radiation. For humans with a skin temperature of 34°, the maximum radiation emittance lies in the near infrared spectrum. With modern thermal detectors that are sensitive for near infrared radiation these signals can be extracted from the environment.

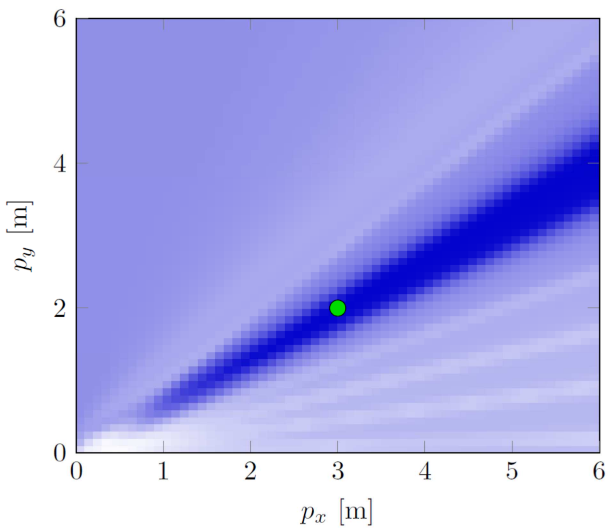

Figure 2 – Likelihood of a sensor node at $(0, 0)$ for a Person standing at (3m, 2m).

Furthermore, by limiting the field of view of the thermopile array pixels with a lens, the sensor output can be transformed to a likelihood that states the most likely position of a heat source. For example, the likelihood of a single person located at (2m, 3m) is plotted in figure 2.

It is obvious that the most likely direction to the heat source has the highest output. Since the signal information provides too few information to calculate the exact distance, the likelihood of at least two ThILo sensor nodes is necessary to determine the approximate position of a single source.

In order to estimate the position of multiple sources, a modified version of a Bayes multi-target filter is used [3]. This filter makes it possible to estimate the position of multiple persons in a medium sized room with a position accuracy of approximately 0.3m.

Since the sensor calibration process is in general a time consuming process, the information provided by the ThILo nodes are used to calibrate the position of the sensors nodes in the surveillance area [4].

References

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