Titel der Ausarbeitung

Autor A, Autor B, Autor C

***Zusammenfassung*—**

***Abstract*—**

I. Einführung

In nature the ability to hear or in other words the ability to gain informations about your environment by sound processing is an essential skill for many animals as well as for humans. Whether it is for hunting prey, for communication, or for drawing attention to potential threads, audition can help solving a variety of different tasks.
In today's world, humans use their ears in road traffic most of the time. At the same time, the technological advances in the development of autonomous cars are making significant progress. It is reasonable to assume that an auditory system could improve even more the performance of autonomous car driving. While most humans use their car horns to communicate warnings, sirens are an important tool for police, fire and rescue services that are using them officially to indicate an emergency. An auditory system can improve the decision-making of the autonomous car based on informations e.g. on the road character, the car condition, and the squealing of the tires.
In the field of robots and sound source localization, auditory systems became an important research field.

In 2003, Valin *et al.* showed that a mobile robot can localize different types of sound sources over a range of 3 m with a precision of 3° in real time using an array of 8 microphones (https://ieeexplore.ieee.org/document/1248813/). By 2016, they were able to localize and track simultaneous different moving sound sources over a range of 7 m using beamforming and particle filtering (https://arxiv.org/abs/1602.08139). Liu *et al.* took a different approach with a biologically inspired spiking neural network for sound localisation ($https://link.springer.com/chapter/10.1007/978-3-540-87559-8_41$) in 2008. Their exprimental results showed that their model could localize a sound source from the azimuth angle, the angle of incidence, -90 to 90 degree. In 2009, Murray *et al.* presented a hybrid architecture using cross-correlation and recurrent neural networks for accoustic tracking in robots ($https://link.springer.com/chapter/10.1007/11521082_5$).Using only two microphones, their model has shown comparable results with the capabilities of the human auditory cortex with the azimuth localisation differing by an average of $\pm 0.4°$. Murase *et al.* used an array of 8 microphones mounted on a mobile robot in order to track multiple moving speaker. Their two key ideas were to use beamforming to locate the sound sources and to use a set of Kalman filters to track the non-linear movements of the speaker ($https://www.isca-speech.org/archive/archive_papers/interspeech_2005/i05_0249.pdf$). The used filters had different history lengths in order to reduce errors under noisy and echoic environments. As a result, multiple moving speakers could be tracked successfully even when speakers and the mobile robot moved non-linearly. So far, most of those systems have in common that they are built to work in closed or crowded environments to interact with people. Focusing on auditive systems for cars, we find that Fazenda *et al.* demonstrated an acoustic based safety emergency vehicle detection for intelligent transport systems in 2009 ($https://ieeexplore.ieee.org/document/5332788/$). Based on a cross microphone array, they were capable of determining the incoming direction of a siren as a sound source. For their suggested array radius, their methods, which were based on time delay estimation, outperformed those, based on calculating the intensity at the microphone array.

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II. Grundlagen

A. Modules of an auditory system

Subsection text.

B. HARK

Subsubsection text.

C. Sound source localization

Subsubsection text.

D. Sound source tracking

Subsubsection text.

E. Sound source separation

Subsubsection text.

F. Filter

Subsubsection text.

G. Integration of HARK in ROS

Subsubsection text.

III. Zusammenfassung

Anhang I
Optionaler Titel

Anhang eins.

ANHANG II

Anhang zwei.

DANKSAGUNG

Wenn ihr jemanden danken wollt, der Euch bei der Arbeit besonders unterstützt hat (Korrekturlesen, fachliche Hinweise,...), dann ist hier der dafür vorgesehene Platz.

LITERATURVERZEICHNIS

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.
[2] Deutsche Forschungsgemeinschaft, *Vorschläge zur Sicherung guter wissenschaftlicher Praxis*, Denkschrift, Weinheim: Wiley-VCH, 1998.