Road Safety - Detection of obstacles with simultaneous distance measurement in poor visibility

TLB
Technologie-Lizenz-Büro
der Baden-Württembergischen Hochschulen GmbH

The invention combines the methods of digital holography and time domain optical coherence tomography to create images of moving objects and their distance in space. This allows the measurement of moving objects in poor visibility conditions when other measurement methods no longer provide clear results.

- Improved visibility in fog and rain, as the light scattered at other distances from the fog particles is not detected interferometrically, as it travels either a shorter or longer path than the light guided in the reference beam (coherence gating).
- The distance, speed and contour data obtained by means of the DHTD lidars lead to a significant improvement in road safety.

Fields of application

This technology can be used in the automotive industry, robotics, construction (road, mining, etc.) and smoke formation (fire brigade).

Background

In road traffic, the automatic recognition of obstacles or other road users with the aid of machine vision is playing an increasingly important role, especially with regard to autonomous vehicles. Therefore it is important that the sensor systems used work reliably and accurately even when visibility is restricted. This means that gapless detection of distances, speeds and contours is needed.

Contact

Dipl.-Ing. Julia Mündel
TLB GmbH
Ettlinger Straße 25
76137 Karlsruhe | Germany
Phone +49 721-79004-0
muendel@tlb.de | www.tlb.de

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Service

Technologie-Lizenz-Büro GmbH has been entrusted with the exploitation of this technology and assists companies in obtaining licenses.

Problem

In poor visibility conditions, such as rain, snowfall or fog, the accuracy and reliability of such systems can decrease significantly or even become meanlingless. Other than the weather, interference from the sensors of other road users, e.g. TOF ("Time-of-flight") or Lidar ("Light detection and ranging"), can also have a negative effect on sensor systems. This is in particular true for conventional sensor systems that use the modulated amplitude, or frequency for for signal evaluation. Currently, the problems of machine vision and automatic detection ofmoving objects in space have not been fully solved for poor visability. The invention aims to solve this problem.

Solution

Researchers at the Institute for Laser Technology in Medicine and Metrology (ILM) at the University of Ulm and the Institute of Applied Optics (ITO) at the University of Stuttgart have developed a method based on optical coherence tomography (OCT) and digital holography. The method allows to detect moving objects and to measure their distances from each other. Compared to classical methods, more details can be displayed when used in a surrounding with poor visibility. This increases the range for which the camera ca be used to resolve objects.

On the basis of optical coherence tomography (OCT), which is often used to measure the fundus of the eye, in particular the retina, a method was developed with which distance measurements in road traffic can be carried out. As a result an axial resolution of a few meters is achieved. The advantage of this distance measurement is that the influence of e.g. fog can be reduced compared to other methods. In general the influence of scattering particles between camera and object can be rduced.

The light source is designed , that the coherence length of the laser is slightly less than the length of a car, see Figure 1. Only in casesthe light paths of the reference beam and the beam reflected back from the obstacle/traffic participant matche to each other within the coherence length, an interference can be registered and a successful fog-suppressed image of the obstacle is be made.

To ensure that the entire measuring range can be recorded within one single shot, the light paths of the reference beam are tuned very quickly. Therefore all measuring sections within the measuring range can be scanned interferometrically. By means of 2D Fourier transformation, the reference beams of different lengths can be separated from each other their position in the Fourier space is then used to determine the distance measured. By separating and reconstructing the corresponding strong signal in Fourier space, the 2D contour of the obstacle can be mapped. The distance measurement can be further refined by using multi-wavelength holography.

Multi-wavelength digital holography is typically used to determine the 3D geometry of components in the µm range. Several wavelengths are used to illuminate the test specimen. By calculating the phase distribution of the backscattered light at the different wavelengths, the shape of the test specimen can be determined, see Figure 2.

According to the invention, at constructive interference, the phase is determined by a Fourier transformation, and subsequently the distance of the object from the detector.

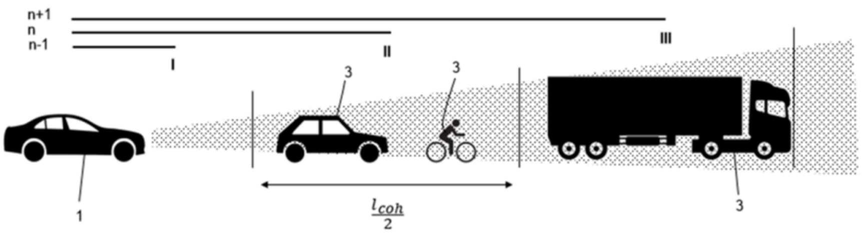

Figure 1: This shows a schematic sketch of a measuring vehicle 1 and three target vehicles 3 driving ahead. A three-dimensional measurement of the scene in front of the measuring vehicle is carried out using the DHTD-LiDAR approach. For this purpose, the area or scene in front of the measuring vehicle 1 is divided into different measuring sections (I, II and III), whereby the extension of the measuring section is specified by half of the coherence length.

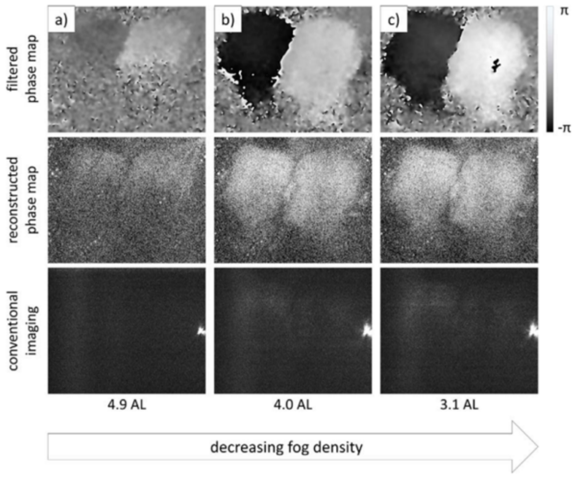

Figure 2: Comparison of DHTD-LiDAR with conventional imaging of 2 styrofoam heads. They are separated by 20cm placed in in an 30m fog tube. From top to bottom: reconstructed phase images using the multi-wavelength method (3D shape), reconstructed amplitude images and conventional images at different fog densities: (a) dense fog, (b) medium fog, (c) light fog (image taken from A. Gröger et al, Two-wavelength digital holography through fog, J. Eur. Opt. Society-Rapid Publ. 2023, 19, 25)

Literature and links

1. Gröger A., Pedrini G., Felix Fischer, Claus D., Alekseenko I., Gloeckler F., Reichelt S., J. Eur. Opt. Society-Rapid Publ. 2023, Two-wavelength digital holography through fog
2. Gröger A., Pedrini G., Claus D., Alekseenko I., Gloeckler F., Reichelt S., Appl. Opt. 62, D68 (2023), Advantages of holographic imaging through fog,