Accurate visual detection and positioning of towed marine seismic devices

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Abstract

Visual object detection as well as tracking is one of the major topics in computer vision. The implementation in marine geophysical exploration leads to an alternative positioning method for the used marine devices. Common used systems for positioning are GPS receivers or transducer systems. Costs for these systems increase rapidly with needed accuracy and objects to be tracked. In this work a visual detection system for positioning of a towed marine hydrophone array is presented. It consists of either a single camera or a stereo camera rig, tracking the movement of receiver related optical reflection bodies behind a research vessel.

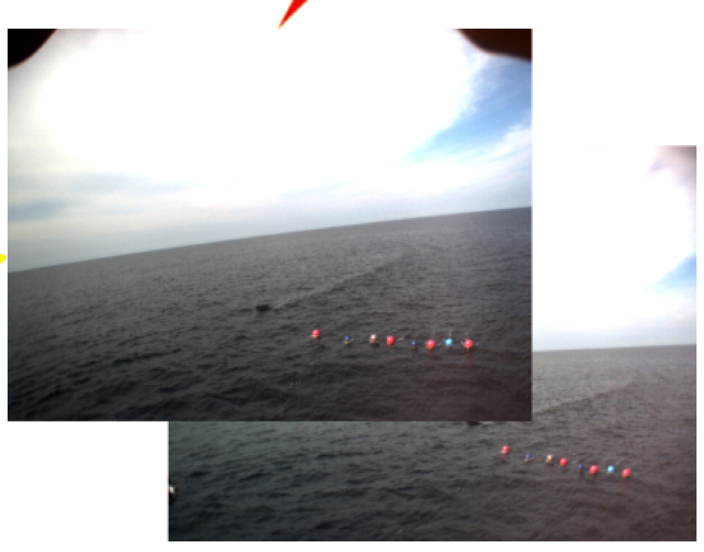
The positions of these objects in the acquired pictures are related to DGPS information, adding inertia sensor data of the ship. Different positioning computations using one camera or a stereo camera rig are compared to each other and reviewed using field data and a synthetic experiment. The synthetic experiments, concerning only the detection and positioning results, show that the accuracy of the developed system is sufficient for positioning of equipment in the marine seismic domain. Using sufficiently accurate GPS and inertia devices the developed system is a low cost alternative for positioning towed marine devices.

System

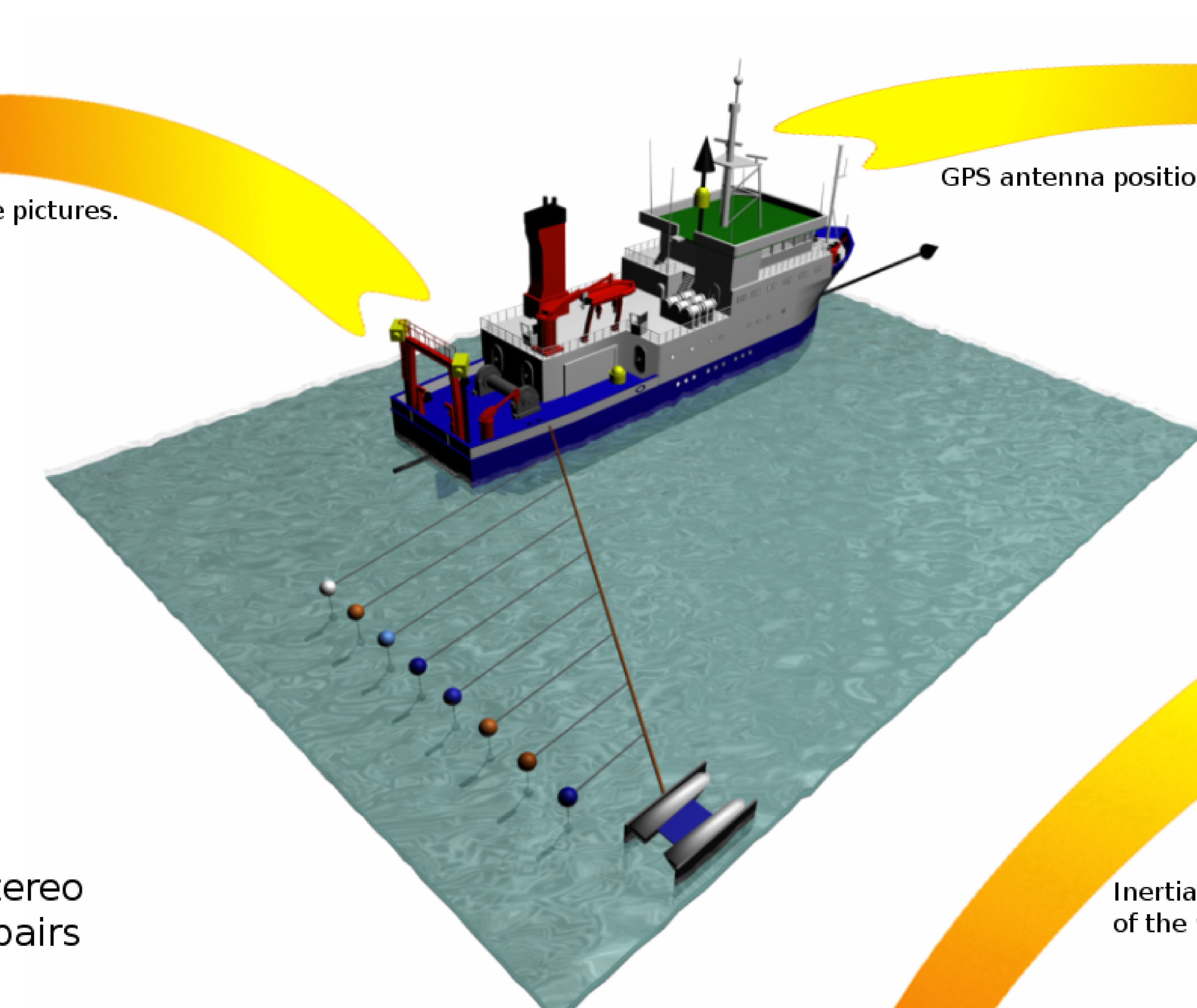
Cameras take pictures.

GPS antenna positions the 3D coordinate system.

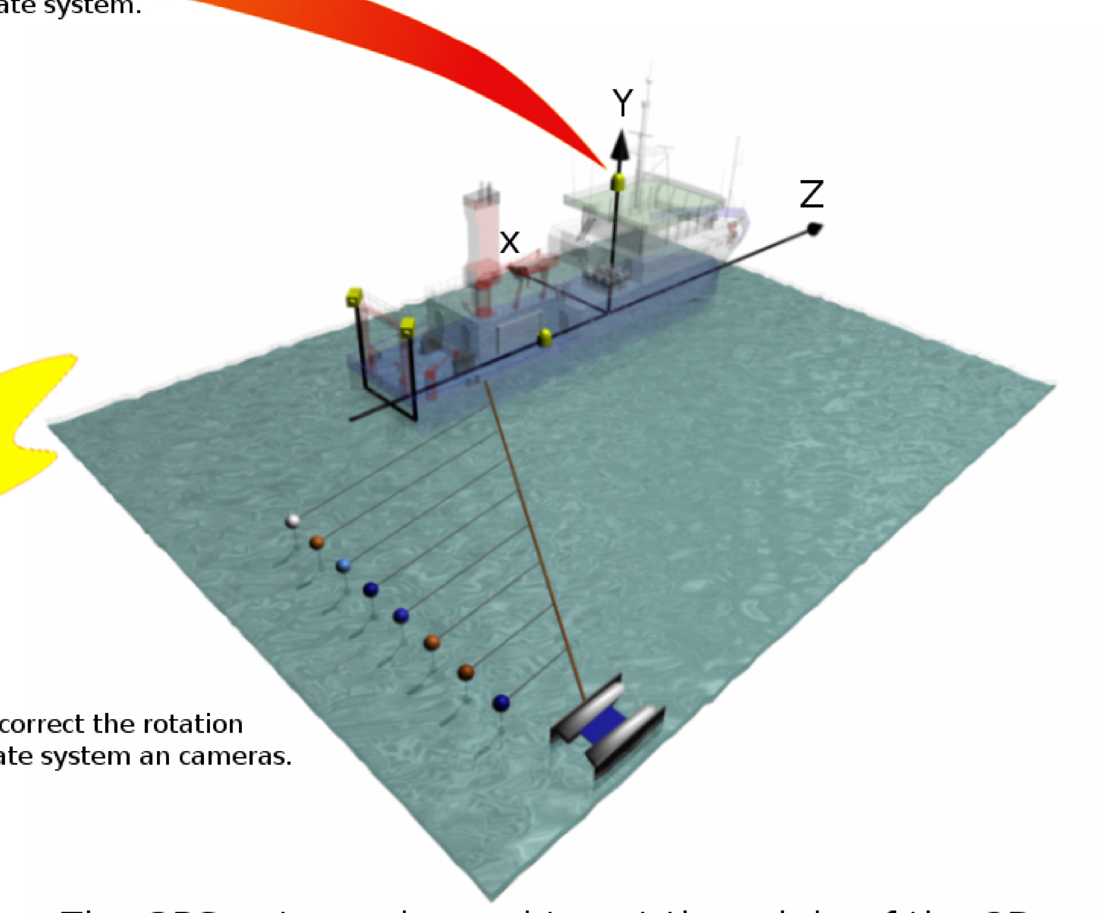
Tracking the floats leads to image coordinates x and y of the floats' midpoints.



A pair of pictures showing the view of the stereo camera system rearwards the ships. These pairs are taken at every source shot.

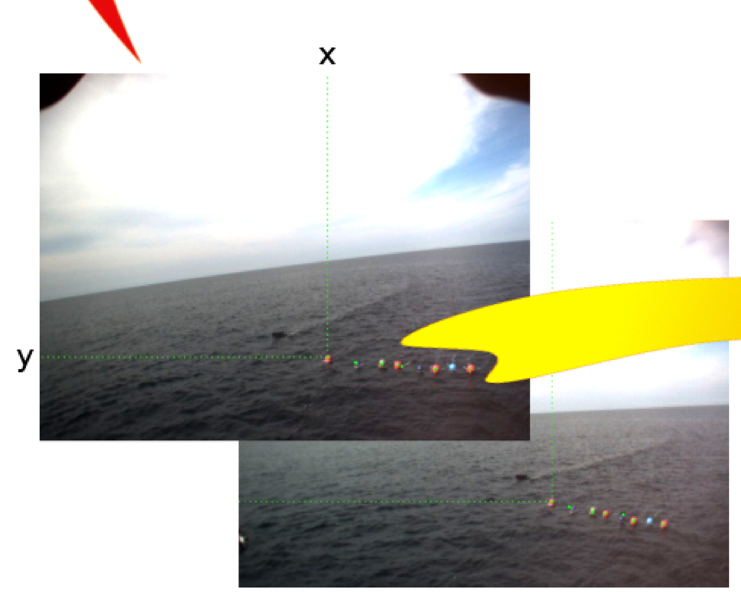


The marine 3D seismic experiment with additional cameras on back, an inertia sensor in the middle and a GPS antenna as high as possible on top of the ship.



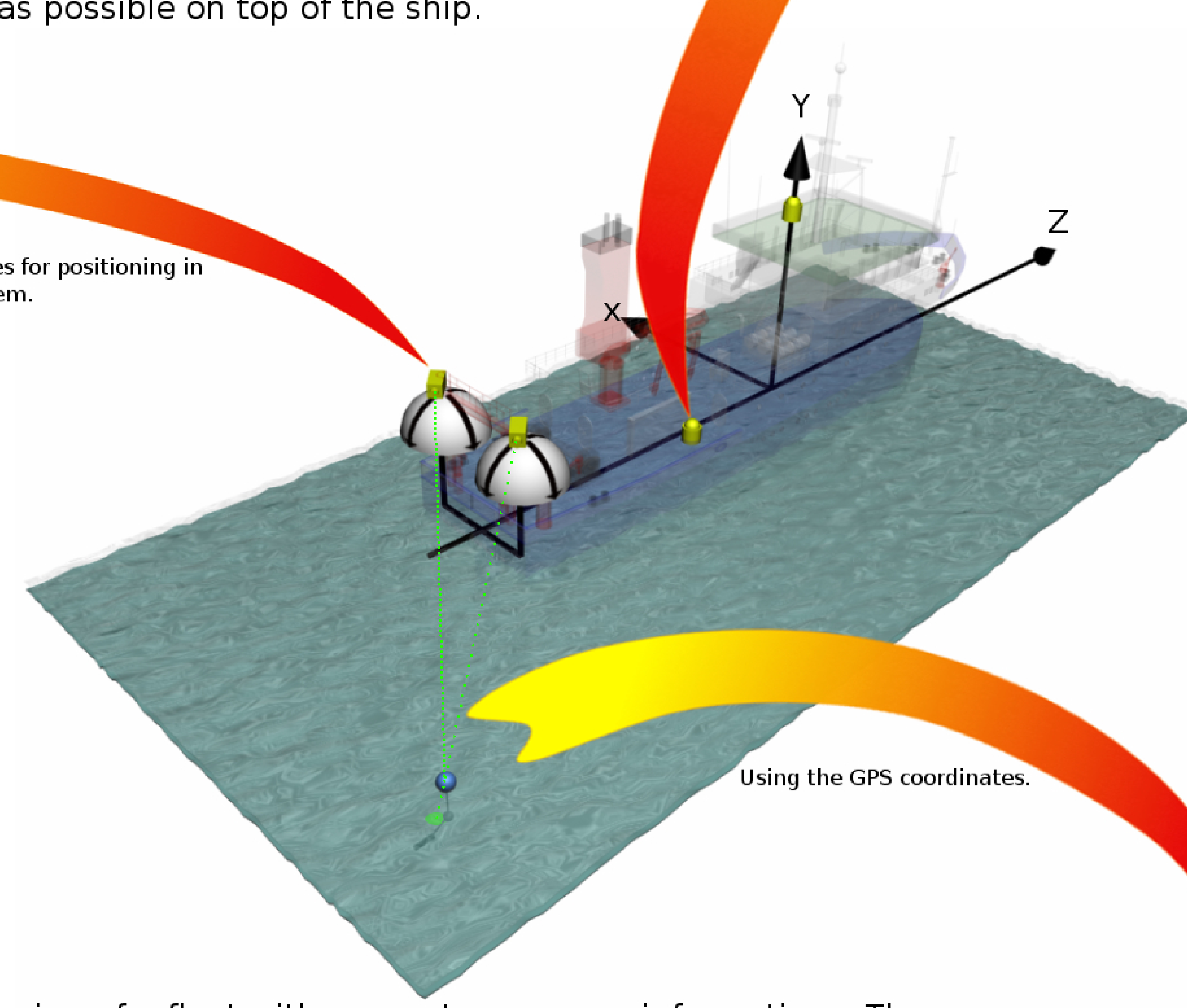
Inertia sensor is used to correct the rotation of the whole 3D coordinate system an cameras.

The GPS antenna is used to set the origin of the 3D coordinate system representing the world in which the cameras are calibrated.



After tracking each of the float the x and y coordinates of their middlepoint are nearly evaluated.

Using image coordinates for positioning in the 3D coordinate system.



Using the GPS coordinates.

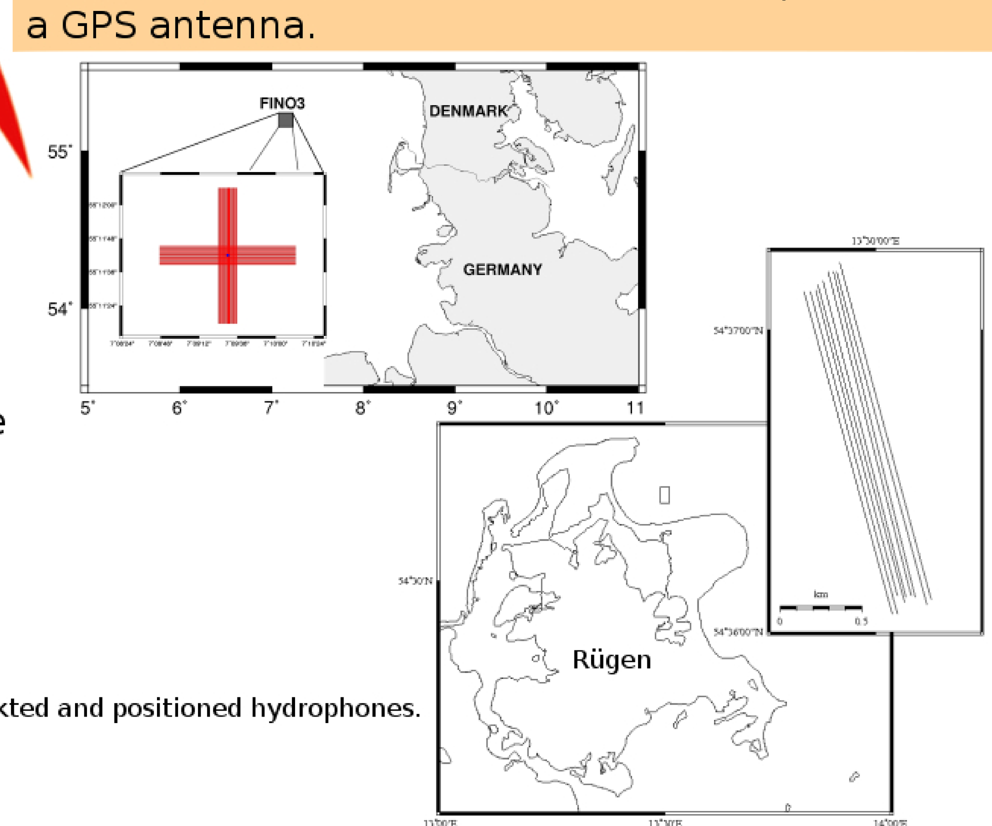
Tracking

A colour histogram in circled form leads to a pattern of coloured balls as floats on the water. All these floats are in the view of both cameras. For each picture, an algorithm is, with respect to some physical constraints, able to search for the floats. The pattern matches best, if its centre will be exactly on the midpoint of the float.
These resulting image coordinates are the x-y-coordinates, which are used for positioning of the floats in the 3D world and thus in GPS coordinates.
The image coordinates in the two images for the same centre of the float are characterised as corresponding image coordinates.

Positioning of a float with one or two camera informations. The one camera positioning intersects the ray through the image coordinates and camera centre with virtual plane (green circle) which is slightly higher than the waterline.
In the two camera system one has the intersection between these two rays. Depending on the visual positioning system, this intersection is the 3D coodinate of the float. Before computing the 3D coordinates, the rotations of the cameras has to be corrected with inertia sensor information.

Positioning

The image coordinates are the input for computing the 3D and thus GPS positions for the floats. These coordinates are given for every picture on the seismic survey, taken on every shot of the seismic source.
Back projecting of these image coordinates off the image to the world leads to a ray starting in the camera centre and going through these coordinates.
Using a one camera system the ray is intersected with a virtual plane slightly higher than the waterline through all centres of the floats.
Using the stereo camera system the intersection of rays through corresponding image coordinates of two images gives the coordinate in the 3D world.
The examined 3D coordinates can be transformed to GPS coordinates, because the centre is positioned by a GPS antenna.



Survey using 3D seismic with visual trackted and positioned hydrophones.

Results and Outlook

The visual detection and positioning is suitable to be uses in VHR 3D seismic. Here even height information can be extracted and used. The accuracy is dependent to the distance of the float. At a distance of 50 meters (m) a miss detection of the midpoint bye one pixel leads to an maximum error of 0.17 meter. If the tracking is free of errors, the accuracy is 0.015 m in X, 0.047m in height and 0.18 m in ship direction. An thus the error of the inertia sensor is important for the accuracy, too. Now the system works offline but the performance would support online use, e.g. saving the extracted positions into the seismic data on the fly.

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http://www.fino3.de

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