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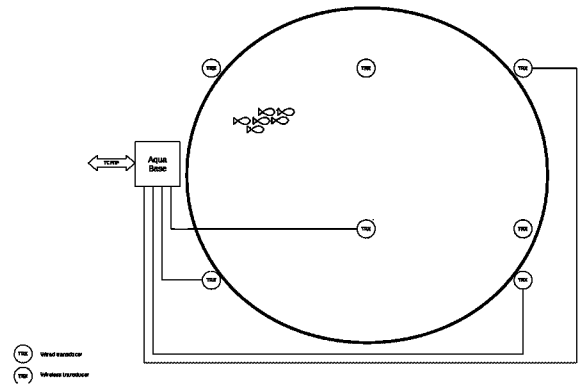
(54) Title **Fish cage hydroacoustic wireless communication and positioning system**

(57) Abstract

Fish cage hydroacoustic wireless communication and positioning system, the system including a base station (10), and at least one hydroacoustic transducer (11a-b) arranged at a fixed location in connection with a fish cage (100) connected to the base station (10) for providing a communication network and local positioning system for units (150a-c) provided with hydroacoustic transducers (12a-b) operating within or in the vicinity of the fish cage (100).



Fish cage hydroacoustic wireless communication and positioning system

The present invention is related to a fish cage hydroacoustic wireless communication and positioning system according to the preamble of claim 1.

The present invention is especially related to a fish cage hydroacoustic wireless communication and positioning system for communication with units or instruments located in the water, in and around fish cages.

Background

Present there are used more "intelligent" instruments/equipment in connection with fish cages. It is an increasing focus on maintenance to reduce, among others, the risk of escapes. Further, the fish cages are exposed to wear and tear due to the harsh maritime environment requiring maintenance, which is desired to perform without the need for retrieving the fish cage from the sea, as well as an overall need for reducing costs. The maintenance is often performed by ROVs, divers or similar, requiring both communication and positioning. To discover the need for maintenance are often cameras used so that one can examine the fish cage visually to discover the need for maintenance.

Further, there is an increased focus on optimal feeding, e.g. there are used cameras in connection with the feeding to ensure that correct amount of fish meal is supplied to the fish cage.

Also automatic feeding arrangements are becoming more and more used, requiring both communication and position. Communication for controlling the amount of fish meal supplied, and positioning to ensure that the fish meal is supplied at the most preferred place in the fish cage. This is often also combined with the use of cameras.

Further there an increased use of sensors informing about the environmental properties in the fish cage for optimizing the production of fish.

Problems with overfeeding/underfeeding in connection with the use of cameras, is mainly due to that one do not have the camera positioned at the correct position at all time, and thus make incorrect observations. Fish meal constitutes the far the largest cost in fish farming, and it is thus large savings to have a solution to this problem. In addition, the release of excess meal into the surroundings has a negative environmental impact.

Presently, also different methods for delousing has been presented involving the use of among others lasers, pumps, controllable skirts and others, requiring communication and control facilities.

There is further a need for wireless communication with e.g. sensors as this will reduce the need for wired equipment in/around the fish cage. Cables are generally unwanted in this environment as they will be in the way for daily operations.

Prior art systems suffer from lack of resolution to provide an acceptable communication and positioning solution, especially in a demanding environment as fish cages. In addition prior art are not arranged to provide the data rates required for transferring real time data from modern sensors (pictures, etc.).

Presently there exist no systems providing a communication and positioning system which is simple and rigid and where units in a simple manner can be integrated.

Accordingly, there is a need for a wireless communication and positioning system which solves the above mentioned problems.

Object

The main object of the present invention is to provide a fish cage hydroacoustic wireless communication and positioning system partly or entirely solving the above mentioned drawbacks of prior art.

It is further an object of the present invention to provide a fish cage hydroacoustic wireless communication and positioning system which in addition to providing a wireless communication network also provides a local positioning system.

An object of the present invention is to provide a fish cage hydroacoustic wireless communication and positioning system where units easily can connect.

It is further an object of the present invention to provide a fish cage hydroacoustic wireless communication and positioning system providing a simple and low-cost solution to wireless communication and positioning under water in and around a fish cage.

A further object of the present invention is to provide a fish cage hydroacoustic wireless communication and positioning system providing high transmission speed for communication.

Another object of the present invention is to provide a fish cage hydroacoustic wireless communication and positioning system providing accurate resolution of positioning.

Further objects will appear from the following description, claims and attached drawings.

The invention

A fish cage hydroacoustic wireless communication and positioning system according to the present invention is described in claim 1. Further advantageous features of the system are described in the remaining claims.

The fish cage hydroacoustic wireless communication and positioning system (FCHWCPS) according to the present invention consists of a base station and at least one hydroacoustic transducer arranged at a fixed location in connection with the fish cage and connected to the base station trough a wire or wireless. The FCHWCPS preferably includes a set of at least two hydroacoustic transducers connected to the base station, and where the hydroacoustic transducers arranged at fixed locations are positioned with a distance between them for increased coverage.

In a further preferable embodiment of the FCHWCPS at least one of the hydroacoustic transducers associated with the base station is arranged at a distance from the water surface to provide a vertical dimension in the FCHWCPS.

Accordingly, the main components of the FCHWCPS are a base station and associated hydroacoustic transducers arranged at fixed locations in connection with the fish cage. The hydroacoustic transducer can be an acoustic transmitter and/or acoustic receiver.

The base station and associated hydroacoustic transducer(s) at fixed location(s) in connection with the fish cage form a wireless communication network and at the same time a local positioning system. As mentioned above, by arranging at least one hydroacoustic transducer at a fixed location below the water surface, i.e. at a distance in the vertical direction of the fish cage, also positioning in the vertical direction can be achieved. Accordingly, the FCHWCPS provides a local 3-Dimensional positioning system.

The wireless communication network will preferably be an ad hoc network, which is a decentralized type of wireless network. Accordingly, each node formed by the hydroacoustic transducer participates in routing by forwarding data for other nodes formed by hydroacoustic transducers. Accordingly, determination of which nodes forward data is made dynamically on the basis of connectivity to the base station.

In fish cages there are many disturbances for the signals between the hydroacoustic transducers, such that it often will be preferable to have at least two hydroacoustic transducers with fixed location, positioned with a distance from each other, so that reliable data can be achieved and communication be performed. E.g. at feeding, a swarm of fish will block the line of sight for the hydroacoustic transducer, requiring that other hydroacoustic transducers can be used in the communication and positioning.

The base station is further provided with a Graphic user interface (GUI) or arranged to a graphic user interface via a TCP/IP connection.

Accordingly, by providing each unit, such as cameras, ROVs, divers, sensors, feeder arrangements or other instruments, to be a part of the FCHWCPS with hydroacoustic transducers, they can both be a part of the wireless communication network and also be positioned in relation to each other and in relation to the hydroacoustic transducers with fixed location.

The local positioning system can thus be used to give 3D coordinates to e.g. cameras, ROVs, divers, sensors or other instruments located in the water in and around fish cages. The wireless communication network can thus be used to transfer data to and from cameras, ROVs, divers, sensors and instruments in the same area.

Positioning of the units with hydroacoustic transducer are performed by measuring time of flight for signals between the different hydroacoustic transducers and perform triangulation between at least two the hydroacoustic transducers with fixed location and the hydroacoustic transducer of the unit. Accordingly, the more hydroacoustic transducers with fixed location the FCHWCPS includes, also in vertical direction of the fish cage, the more precisely the unit can be positioned.

The hydroacoustic transceivers are preferably arranged at a distance below the water surface to avoid disturbance due to waves at the sea surface, as well as protecting the hydroacoustic transducers from the environment.

By using hydroacoustic transducers with coverage in given sectors or with 360 degrees coverage, a communication network within and around the fish cage can be achieved, and at the same time a local positioning system is achieved for the same.

Accordingly, when a unit is to be included into the FCHWCPS, the hydroacoustic transceiver of the unit sends a request to the base station via the hydroacoustic transducer at fixed location and if it is not in range of the hydroacoustic transducers with fixed location attempts to send the request via hydroacoustic transducers of other units, whereupon the unit is assigned an ID if the properties of the request are accepted, whereupon the unit becomes a node in the FCHWCPS.

The problems one is facing with underwater communication and positioning is mainly associated with reflection, attenuation, dispersion (scattering) and Doppler effects. All of these problems are reinforced further in the environment in and around a fish cage. This is mainly due to the biomass of the fish and its movement, but also due to growing/algae, as well as mechanical challenges which arises in the surface zone.

According to the present invention the hydroacoustic transducer are preferably high-quality digital hydrophones which provide less noise sensitivity and higher sensitivity, necessary to be able to perform positioning in a demanding environment as described above.

The base station is preferably further arranged for providing a configurable frequency area so that one is not locked to a certain frequency or frequency band, but according to the present invention the base station can be controlled for configuring/choosing frequency based on the environment the system is to operate in.

Further, the system according to the present invention is further arranged for performing digitalization of the hydroacoustic transducer in the transducer itself, reducing, among others, crosstalk problems arising in connection with wires over the dimensions one find in a fish cage.

The base station according to the present invention is further arranged for providing the system with adaptive communication speed, such that the system at all time will maximize the transfer speed for a given communication channel (distance, signal-to-noise-ratio, etc.).

The base station according to the present invention is further arranged for Real-time FPGA signal processing providing a time resolution at nanosecond level.

Further preferable features and advantageous details of the present invention will appear from the following example description, claims and attached drawings.

Example

The present invention will below be described in further detail with references to the attached drawings, where:

Figure 1 is a principle drawing of a fish cage hydroacoustic communication and positioning system (FCHWCPS) according to the present invention, and

Figure 2 is a block diagram of the FCHWCPS showing flow of signals and data in the FCHWCPS.

Reference is now made to Figure 1 which is a principle drawing of a fish cage hydroacoustic communication and positioning system (FCHACPS) according to the present invention.

The FCHACPS main components are a base station 10 and a set of hydroacoustic transducers 11a-b, preferably in the form of high-quality digital hydrophones, arranged with fixed location in connection with a fish cage 100. In a further embodiment of the system according to the present invention the hydroacoustic transducers are arranged for digitalization of signals before transfer. In the shown example there are arranged three hydroacoustic transducers 11a with fixed location connected to the base station 10 by means of wires, the hydroacoustic transducers 11a being arranged at an exterior surface of the fish cage 100, typically arranged to a fixed construction of the fish cage 100. In addition there are arranged one hydroacoustic transducers 11b wirelessly connected to the base station 10, arranged in a fixed position at distance below water surface to allow positioning also vertical direction.

Accordingly, by the base station 10 and the hydroacoustic transceivers 11a-b there are provided a communication network in the fish cage 100 and in an area around the fish cage 100. Further, the base station 10 and hydroacoustic transceivers 11a-b in addition to a communication network provide a local positioning system both in the fish cage 100 and in an area around the fish cage 100.

The figure further shows the interaction with three units 150a-c, each unit being provided with a wired hydroacoustic transceiver 12a or wireless transceiver 12b. E.g. the unit 150a can be a camera, the unit 150b can be a feeding arrangement and unit 150b can be an ROV.

The base station 10 is arranged for controlling the communication of data, and further provided with means and/software for calculating relative position of units 150a-c provided with hydroacoustic transducers 12a-b in the fish cage 100 or in the vicinity of the fish cage 100, based on time of flight for acoustic signals and triangulation. The base station 10 is further provided with

means and/or software for providing a configurable frequency area so that the base station 10 can be controlled for configuring the network to a frequency based on the environment the system is to operate in.

The base station 10 can further be provided with means and/or software for adaptive communication speed such that the system at all time maximize the transfer speed for a given channel.

The base station 10 is preferably provided with means and/or software for Real-Time FPGA signal processing enabling time resolution at nanosecond level.

Reference is now made to Figure 2 which is a block diagram showing flow of data and signals in the FCHACPS. The base station 10 is provided with a graphic user interface (GUI) 200 or arranged to an external graphic user interface (GUI) 200. The figure show the flow of data and signals in the FCHACPS between GUI 200 and three units 150a-c. E.g. data can be transmitted from GUI 200 to unit 150c, such as a ROV, from unit 150b, such as a camera, to GUI 200 and at the same time the relative position of unit 150a and 150b, such as a feeding arrangement, are calculated and displayed. Dashed arrows represent acoustic links.

As at least one of the hydroacoustic transducers 11a-b, 12a-b are arranged in a fixed location in connection with the fish cage 100, and if one of the hydroacoustic transducers 11a-b, 12a-b or units 150a-c is provided with a GPS (Global Positioning System) or GNSS (Global Navigation Satellite System) also the absolute position of the units 150a-c can be determined.

Accordingly, by the present invention is provided a system which by the combination of both communication and positioning will support transfer of real time data from mobile, sensor-carrying nodes, such as an inspection node.

Further, by the present invention it will be possible to perform automatic positioning of several units in relation to each other, such as e.g. a feeding camera and feeder, such that the need for manual control of the feeding camera is not necessary.

Accordingly, by the present invention is provided a system which can be integrated with environmental sensors with hydroacoustic transducers being positioned in in the fish cage, and in this way provide more detailed environmental data than traditional log stations which there usually are not more than one of per plant.

Claims

1. Fish cage hydroacoustic wireless communication and positioning system, **characterized by** that the system includes a base station (10), and at least one hydroacoustic transducer (11a-b) arranged at a fixed location in connection with a fish cage (100) connected to the base station (10) for providing a communication network and local positioning system for units (150a-c) provided with hydroacoustic transducers (12a-b) operating within or in the vicinity of the fish cage (100).

2. Fish cage hydroacoustic wireless communication and positioning system according to claim 1, **characterized by** that the system includes a set of at least two hydroacoustic transducers (11a-b) connected to the base station (10), the hydroacoustic transducers (11a-b) being arranged at fixed locations in connection with the fish cage (100).

3. Fish cage hydroacoustic wireless communication and positioning system according to claim 2, **characterized by** that the hydroacoustic transducers (11a-b) are arranged to the fish cage (100) displaced from one another.

4. Fish cage hydroacoustic wireless communication and positioning system according to claim 2, **characterized by** that at least one of the hydroacoustic transducers (11a-b) is displaced in vertical direction of the fish cage (100).

5. Fish cage hydroacoustic wireless communication and positioning system according to claim 1, **characterized by** that at the base station (10) is provided with means and/or arranged for controlling the communication in the communication network and calculating relative position between units (150a-c) connected to the communication network.

6. Fish cage hydroacoustic wireless communication and positioning system according to any one of the preceding claims, **characterized by** that the hydroacoustic transducers (11a-b, 12a-b) are high-quality digital hydrophones.

7. Fish cage hydroacoustic wireless communication and positioning system according to any one of the preceding claims, **characterized by** that the hydroacoustic transducers (11a-b, 12a-b) are arranged for digitalization of signals before transfer.

8. Fish cage hydroacoustic wireless communication and positioning system according to any one of the preceding claims, **characterized by** that the base station (10) is provided with means and/or software for one or more of:

- providing a configurable frequency area for the communication network,

- providing adaptive communication speed for the communication network,

- Real-Time FPGA signal processing enabling time resolution at nanosecond level.

9. Fish cage hydroacoustic wireless communication and positioning system according to any one of the preceding claims, **characterized by** that the one or more hydroacoustic transducers (11a-b, 12a-b) or units (150a-c) are provided with a Global Positioning System or Global Navigation Satellite System.

10. Fish cage hydroacoustic wireless communication and positioning system according to any one of the preceding claims, **characterized by** that that the hydroacoustic transducers (11a-b, 12a-b) are arranged for forwarding of data from other hydroacoustic transducers (11a-b, 12a-b).

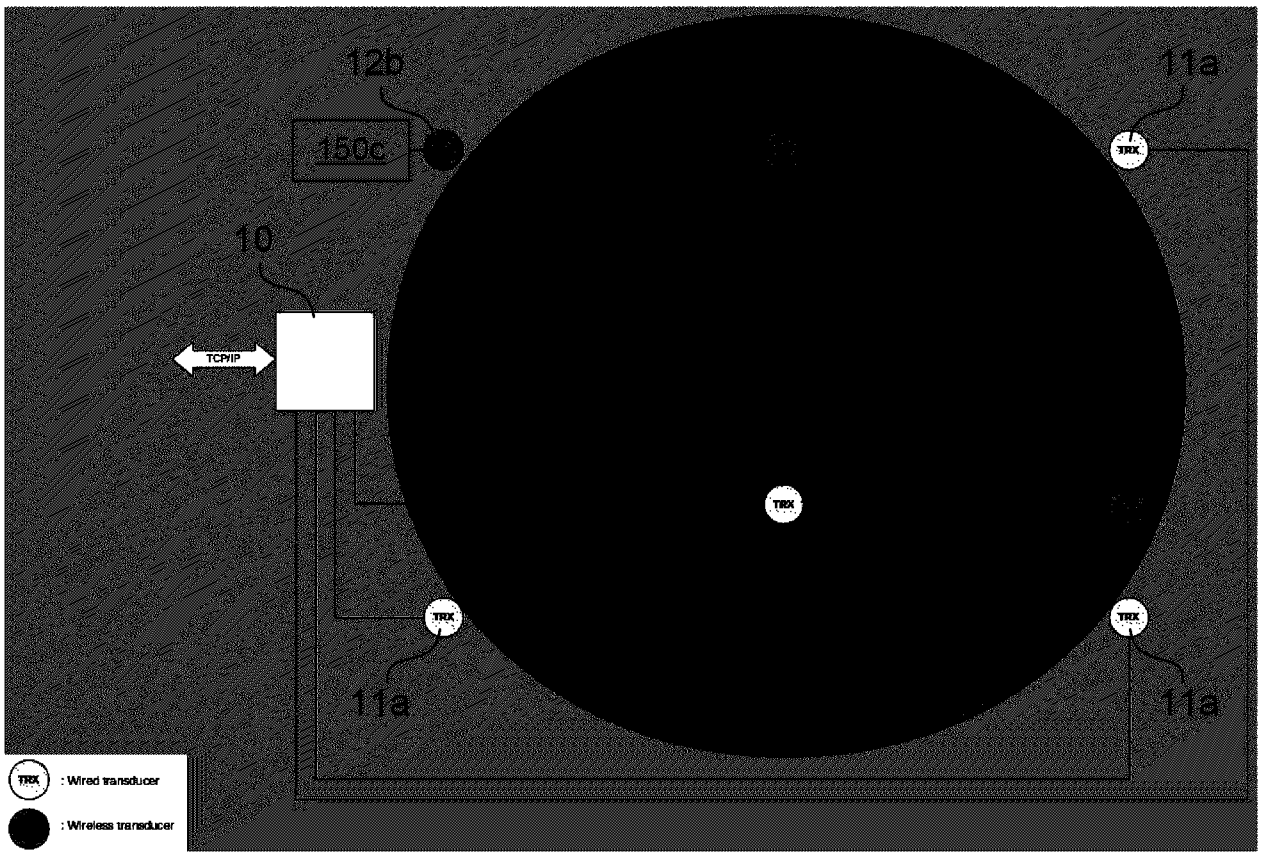

12b
11a
150c
10
TCP/IP
TRX
11a
11a
TRX : Wired transducer
: Wireless transducer

Fig. 1.

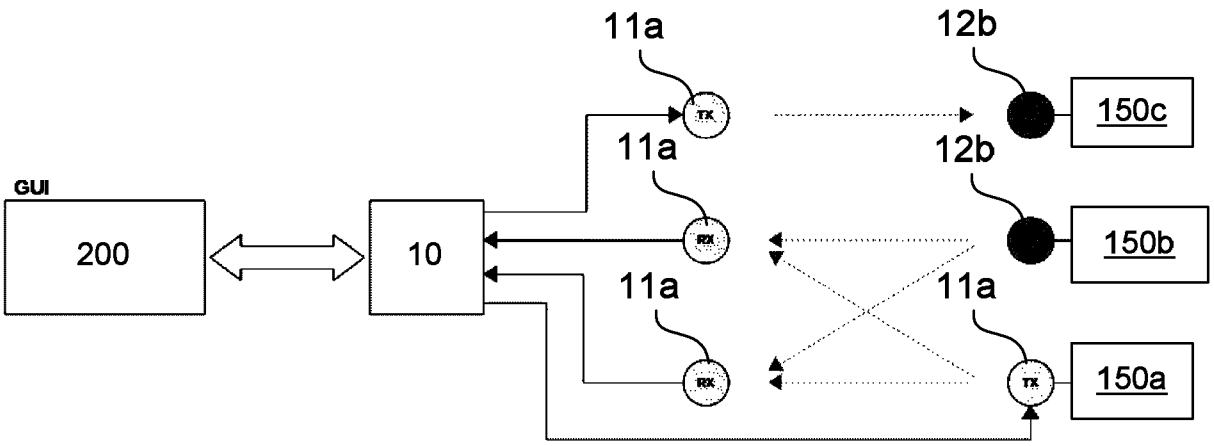


Fig. 2.