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(54) **VEHICLE CONTROL SYSTEM FOR WATERCRAFT USING A MICROCHIP BASED PROCESSOR AND CONTROL SURFACES**

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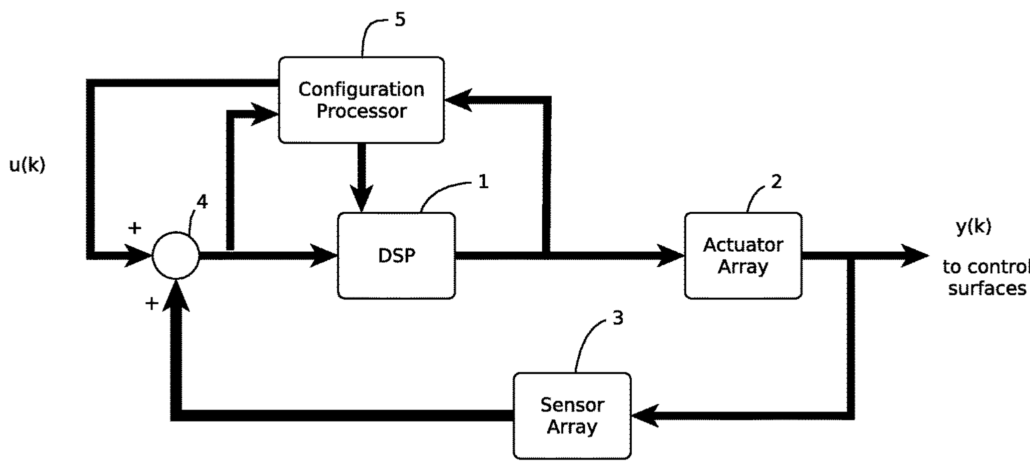
(57) **ABSTRACT**

The invention is a vehicle control system which is envisaged to be used in high speed planing watercraft which has a means of control about three axes where the invention controls the said watercraft about at least two axes by actuating control surfaces. The invention uses a microchip based processor (**1**) to actuate control surfaces based on input from various sensors (**3**). The invention also uses a three dimension time of flight imaging subsystem (**8**) to read information of the oceanic wave conditions.



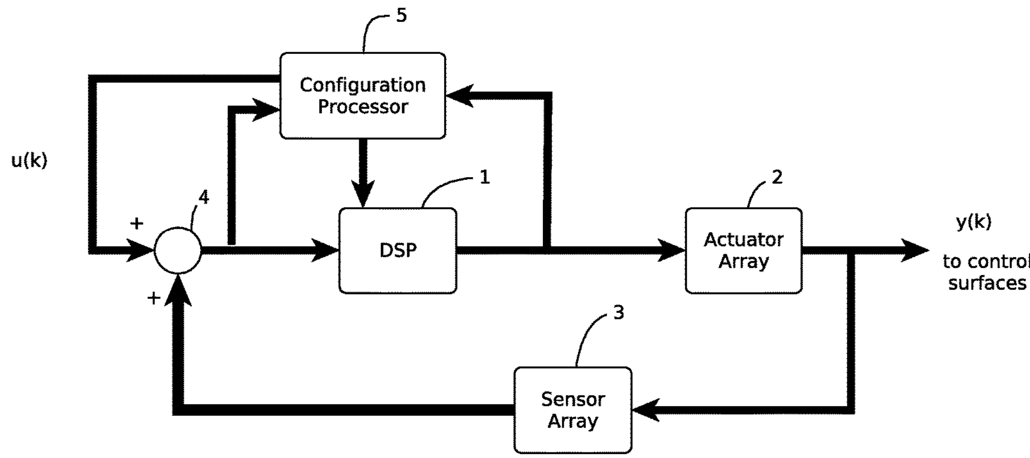


Figure 1

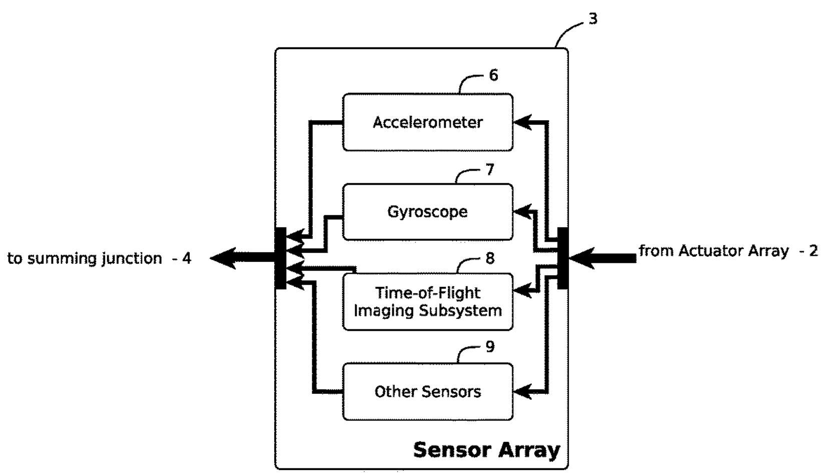


Figure 2

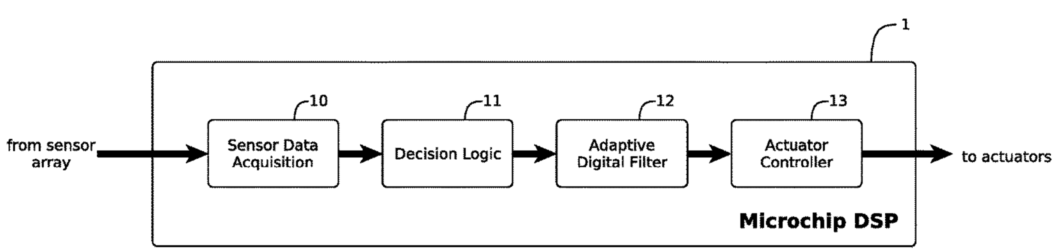


Figure 3

VEHICLE CONTROL SYSTEM FOR WATERCRAFT USING A MICROCHIP BASED PROCESSOR AND CONTROL SURFACES

TECHNICAL FIELD

[0001] The invention relates to a vehicle control system using a microchip based processor which is envisaged to be used in high speed planing watercraft which has a means of control about three axes where the said vehicle control system actively controls the said watercraft about two axes by actuating control surfaces based on oceanic wave conditions.

BACKGROUND OF THE INVENTION

[0002] Most water based craft have control surfaces on only one axis which is commonly referred to as rudders. However, with increased speeds of water craft this is no longer sufficient. Control surfaces to control the watercraft on another two axes are required especially at very high speeds where roll and pitch of the craft become extremely important.

[0003] The current hydroplane watercraft still crash as they did when they were first built almost a hundred years ago because of a loss of vehicle control about the two axes where there are no means to exert any direct corrective control of the vehicle. This loss of control may be due to as little as a small wave or gust of wind.

[0004] Watercraft traditionally requires only throttle and rudder controls. For very high speed watercraft both throttle and rudder controls are controlled separately by two different persons. It should therefore be expected that the control of the watercraft about another two axes should be done electronically and not by yet another person as coordination between the three human controllers becomes another safety issue. A vehicle control system which actuates control surfaces to control both roll and pitch of a high speed watercraft based on the wave conditions is imperative for safety and comfort whilst still allowing manual directional control of the watercraft via the rudder. Furthermore, with this superior control system, watercraft equipped with this vehicle control system will be able to travel faster and more safely whilst providing greater passenger comfort which was simply not possible before.

SUMMARY OF THE INVENTION

[0005] The invention is a vehicle control system for watercraft which uses a microchip based processor to actuate control surfaces via input from an array of sensors. These sensors are able to provide information on position, speed, direction of the watercraft but also provide information on the components of force on the hull of the said watercraft whilst the said watercraft is travelling at speed.

[0006] Furthermore, optical sensors are able to determine colour patterns of the waves to detect water debris. Three dimensional time of flight imaging subsystems are able to provide three dimensional near real-time information of wave conditions. The microchip based processor monitors information for all the various sensors and adjusts the control surfaces such that the watercraft maneuvers over the waves with minimal impact on the hull.

[0007] The invention is expected to be used in watercraft which have controls about three axes of which the invention actively controls at least two axes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In order that the invention may be more readily understood and put into practical effect, a preferred example of the invention will now be described with reference to the accompanying drawings, in which:

[0009] FIG. **1** is an automatic feedback control system block diagram of the invention.

[0010] FIG. **2** illustrates the various sensors in the sensor array **3**

[0011] FIG. **3** illustrates the various subsystems of the Digital Signal Processor (DSP) **1**

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0012] The system shown in FIG. **1** includes a group of sensors, collectively called sensor array **3**, which picks up signals from the environment and feeds the information to the Digital Signal Processor (DSP) **1**. The DSP **1** in the preferred embodiment is a specialised type of microchip based processor optimized for digital signal processing.

[0013] The sensor array **3** is a group of one or more sensors which are further illustrated in FIG. **2**. The DSP **1** reads these signals and makes decisions as to how to actuate the control surfaces via a fault tolerant system of actuators **2**. Each individual actuator may receive digital or analogue signals, depending on the type and design of the actuator. If an actuator is designed to receive analogue signals, it is attached to a digital-to-analogue converter (DAC) circuit.

[0014] Based on information received from the sensor array **3**, the digital signal processor **1** makes decisions on how to best actuate the actuators **2** which in turn would drive the control surfaces that control the movements of a watercraft. In FIG. **3**, decisions from decision logic **11** are fed to an adaptive digital filter **12** whose purpose is to smoothen the trajectory control decisions made by the decision logic **11**. The smoothed trajectory will be fed to the actuator controller **13** which would then encode the actual trajectory signals for the actuators **2**.

[0015] The time-of-flight imaging subsystem (TOF) **8**, accelerometer **6**, gyroscope **7** and other sensors **9** including but not limited to optical sensors, ultrasonic and laser distance sensors in FIG. **2** provide the DSP **1** the situational awareness of the environment which the said watercraft will experience. In this regard, oceanic waves, other watercraft and water debris form the key environmental factors which the invention monitors and reacts to. The accelerometer **6** senses acceleration and provides the DSP **1** details on the impact the said watercraft is experiencing from the waves. The vehicle control system will therefore already have situational awareness about the oceanic wave periods and average oceanic wave heights based on the repeated accelerometer readings each time the watercraft encounters a wave. The TOF **8** provides further data on oceanic waves the said watercraft will experience; TOF **8** gives an advanced look ahead especially for rogue oceanic waves which may affect the said watercraft which the accelerometer **6** is unable to predict. TOF **8** provides a map of the surroundings of the watercraft and constantly updates the DSP **1** in conjunction with gyroscope **7**. The gyroscope **7** provides orientation information as well as senses angular acceleration about three axes. Thus, the gyroscope **7** provides the situational awareness to the DSP **1** on where the watercraft is in relation to the map of oceanic wave surroundings created by TOF **8**. After the DSP **1** actuates the control surfaces, the accelerometer **6** and gyroscope **7** also provides the DSP **1** feedback on the impact of the hull and angular acceleration of the said watercraft respectively. Thus adaptive control is possible for the DSP **1** which means situational awareness and the control inputs to the actuators **2** which actuate the control surfaces which control the said watercraft constantly improve. Thus, the invention allows the said watercraft it controls, to travel extremely fast over oceanic environments safely and comfortably which is a feat which has not been possible before. This in essence is what is meant by the closed loop automatic feedback control system illustration of the invention in FIG. **1**.

[0016] The DSP **1** does need some initial parameters and rule sets before this adaptive control can achieve desirable results quickly. Thus, a configuration processor **5** allows external initial parameters to be populated into the DSP **1**. The configuration processor **5** also allows the invention to be customised in real-time. This means the user may choose between different modes of operations; for example comfort mode or performance mode. The configuration processor **5** supplies initial conditions (denoted by u(k)) to the control system, and initial parameters to the DSP **1**. The configuration processor **5** provides a means for a human user to control the behaviour of the entire system. The result of the DSP **1** can be summarised by the configuration processor **5**, which can then be sent to a display panel or any multimedia device to be perceived by the controlling human.

[0017] DSP **1** obtains bearing, air speed, water speed, propulsion information, obstructions and other environmental factors from the other sensors **9** which is also included in this adaptive control process. Furthermore, the configuration processor **5** also allows sensor input thresholds to be defined such that if these thresholds were exceeded, the DSP **1** would save a snapshot of the environment via the sensors array **3** at that particular time which can be later extracted via the configuration processor **5** and further analysed together with data from the same control system from other watercraft.

[0018] The DSP **1** and configuration processor **5** may be implemented within a field-programmable gate array (FPGA) and also within an application-specific integrated circuit (ASIC) either separately or combined.

[0019] The TOF **8** requires more connections or a higher speed connection to the DSP **1** because it provides large amounts of data compared to the other sensors which provide mostly provide one value at a time.

[0020] While the invention has been particularly shown and described with reference to the preferred embodiment thereof, it will be understood by those skilled in the art that various change in forms and details may be made therein without departing from the spirit and scope of the invention.

[0021] The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A vehicle control system for controlling a planing watercraft using at least one microchip based processor (**1**), at least one actuator (**2**) and at least one sensor (**3**) where there are means to actively control the said planing watercraft about three axes and the said at least one microchip based processor (**1**) controls the said watercraft about at least two axes via the said at least one actuator (**2**) based on input the said at least one microchip based processor (**1**) receives from the at least one sensor (**3**).

2. A vehicle control system as in claim **1** where the said watercraft has at least three control surfaces where the said at least one microchip based processor (**1**) actively controls at least two control surfaces via the said at least one actuator (**2**).

3. A vehicle control system as in claim **2** where the said watercraft is also able to operate in ground effect.

4. A vehicle control system as in claim **2** where at least one of the said at least one microchip based processor (**1**) is a digital signal processor.

5. A vehicle control system as in claim **2** where at least one of the said at least one microchip based processor (**1**) is a field-programmable gate array.

6. A vehicle control system as in claim **2** where the said at least one microchip based processor (**1**) is an application-specific integrated circuit.

7. A vehicle control system as in claim **2** where there is at least one accelerometer (**6**) present.

8. A vehicle control system as in claim **2** where there is at least one gyroscope (**7**) sensor present.

9. A vehicle control system as in claim **2** where there is at least one sensor (**9**) able to provide information on distance from an object detected by the said sensor to the said watercraft.

10. A vehicle control system as in claim **2** where there is at least one optical sensor (**9**).

11. A vehicle control system as in claim **9** where there is at least one subsystem (**8**) able to provide three dimensional imaging information to the said at least one microchip based processor.

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