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United States Patent Application Publication	20250256810
Kind Code	A1
Publication Date	August 14, 2025
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POWERED HYDROFOIL BOARD WITH INTEGRATED CONTROL FLAP

Abstract

A hydrofoil board having a hydrofoil configured to be automatically controlled to stabilize the board in a level position even when incurring waves. The hydrofoil includes a pair of individually controllable flaps that control the pitch and direction of the hydrofoil board when propelled in motion. A processor uses an inertial measurement unit (IMU) to obtain orientation and acceleration information of the hydrofoil board. A global positioning system (GPS) unit is also used as an additional speed and location sensor. The processor combines IMU data with a user/rider's input, such as selected speed and direction via handheld wireless controller, and individually controls the flap motors to position the flaps, and the propulsion motor to set speed. In one example, the controller is configured to bring the hydrofoil board to a complete and stabile stop.

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Family ID: **1000008575043**

Appl. No.: **19/192204**

Filed: **April 28, 2025**

Related U.S. Application Data

parent US continuation 17538317 20211130 parent-grant-document US 12330748 child US 19192204
us-provisional-application US 63131386 20201229

Publication Classification

Int. Cl.: **B63B1/24** (20200101); **B63B1/28** (20060101)

U.S. Cl.:

CPC **B63B1/246** (20130101); **B63B1/242** (20130101); **B63B1/28** (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a Continuation of U.S. Ser. No. 17/538,317 entitled POWERED HYDROFOIL BOARD WITH INTEGRATED CONTROL FLAP, filed on Nov. 30, 2021, which claims priority to U.S. Provisional Application Ser. No. 63/131,386 entitled POWERED HYDROFOIL BOARD WITH INTEGRATED CONTROL FLAP, filed on Dec. 29, 2020, the contents of all of which are incorporated fully herein by reference.

TECHNICAL FIELD
[0002] The present disclosure generally relates to powered hydrofoil boards.
BACKGROUND
[0003] Powered hydrofoil boards typically included a floatable board, a downwardly extending strut, a propulsion mechanism, and a hydrofoil.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0004] In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. Some examples are illustrated by way of example, and not limitation, in the figures of the accompanying drawings in which:
[0005] FIG. **1** illustrates a perspective view of a hydrofoil board;
[0006] FIG. **2** illustrates a perspective view of a hydrofoil including individually controllable flaps;
[0007] FIG. **3** illustrates a cross sectional view of the hydrofoil taken along line **3-3** in FIG. **2**;
[0008] FIG. **4** illustrates a control system for controlling the hydrofoil board; and
[0009] FIG. **5** illustrates a method of the controller operating the hydrofoil board.
DETAILED DESCRIPTION
[0010] This disclosure provides a hydrofoil board having a hydrofoil configured to be automatically controlled to stabilize the board in a level position even when incurring waves. The hydrofoil includes a pair of individually controllable flaps that control the pitch and direction of the hydrofoil board when propelled in motion. A processor uses an inertial measurement unit (IMU) to obtain orientation and acceleration information of the hydrofoil board. A global positioning system (GPS) unit is also used as an additional speed and location sensor. The processor combines IMU data with a user/rider's input, such as selected speed and direction via handheld wireless controller, and individually controls the flap motors to position the flaps, and the propulsion motor to set speed. In one example, the controller is configured to bring the hydrofoil board to a complete and stabile stop.
[0011] Additional objects, advantages and novel features of the examples will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following and the accompanying drawings or may be learned by production or operation of the examples. The objects and advantages of the present subject matter may be realized and attained by means of the methodologies, instrumentalities and combinations particularly pointed out in the appended claims.
[0012] The description that follows includes systems, methods, techniques, instruction sequences,

and computing machine program products illustrative of examples of the disclosure. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide an understanding of various examples of the disclosed subject matter. It will be evident, however, to those skilled in the art, that examples of the disclosed subject matter may be practiced without these specific details. In general, well-known instruction instances, protocols, structures, and techniques are not necessarily shown in detail.

[0013] The examples illustrated herein are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed. Other examples may be used and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. The Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various examples is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0014] Reference now is made in detail to the examples illustrated in the accompanying drawings and discussed below.

[0015] Referring to FIG. **1** there is shown a top perspective view of a hydrofoil board **10** including an elongated floatable board **12**. Board **12** is generally planar and has a top surface **14** configured to support a user who rides the board. A front portion is tapered to a front end **16**, and a rear portion is tapered to a rear end **18**. A pair of board sides **20** are tapered outwardly and may include a respective handle **22**.

[0016] Also shown in FIG. **1** is a strut **30** securely coupled to a bottom surface of the board **12** at a rear central portion of the board **12**. The strut extends from an upper end **32** to a lower end **34**. A body **36** is securely coupled to the strut **30** proximate the lower end **34** and extends longitudinally rearward to a body end. A propulsion system is coupled to the body end **18** and is configured to selectively propel the hydrofoil board **10** forwardly above the water. In an example, the propulsion system is electrically powered by a battery **42** positioned in a storage compartment **44** located at the board rear end **18**. In one example the propulsion system includes an electric motor **46** (FIG. **4**) positioned in body **36** and is drivingly coupled to a propeller **48**. The propulsion system is selectively controlled by the user to control speed of the hydrofoil board **10** using a wireless controller **50** having buttons or a touchpad.

[0017] The hydrofoil board **10** also includes a stabilizer system generally shown at **60** and including a stabilizer bar **62** coupled to the strut lower end **34**. The stabilizer bar **62** extends longitudinally and generally parallel to the body **36** and has a front end **64** and a rear end **66**. The stabilizer system **60** is configured to provide ride stability when the hydrofoil board **12** is propelled above the water. The stabilizer system **60** also includes a hydrofoil **68** coupled to the bar front end **64** and that is formed as a wing positioned horizontally, and generally parallel to the board **12**. A tail **70** is coupled to the bar rear end **66** and is also formed as a wing that is smaller than the hydrofoil **68**. Both the hydrofoil **68** and the tail **70** are designed similar to an airplane wing and which has a smooth leading edge and is tapered rearwardly to reduce drag in the water as they pass through the water. Hydrofoil boards consisting of the hydrofoil **68** and tail **70** are controlled directly by the rider shifting his or her weight to change the angle of the hydrofoil **68**. This technique requires constant attention and input from the rider and is especially challenging in waves.

[0018] Referring to FIG. **2**, there is shown a perspective view of the hydrofoil **68** having a left flap **72** and a right flap **74** configured to be selectively controlled by an electronic processor **100** (FIG. **4**) to automatically stabilize, and steer, the hydrofoil board **10**, such as in wavy or winding conditions. The flaps **72** and **74** also reduce the strain on a user when trying to stabilize and control the hydrofoil board **10**, either in smooth or wavy conditions. In one example, the flaps **72** and **74** are configured to help bring the hydrofoil board **10** to a stop, which is generally a difficult task. The flaps **72** and **72** are similar to ailerons of an airplane, and they are configured to selectively provide lift to control pitch of the hydrofoil board **10** when positioned together in the same direction, as well as to steer the hydrofoil board **10** when one flap is positioned in one direction, or when both flaps are positioned in opposite directions. In an example, the flaps **72** and **74** can both be positioned by processor **100** upward or downward to control pitch and automatically bring the hydrofoil board **10** to a controlled stop. To turn the hydrofoil board **10** left, the left flap **72** can be moved upward, and the right flap moved downward. In another example, the flaps **72** and **74** can be coupled to the tail **70** in a similar manner to control pitch and steering. In another example, flaps can be provided on both the hydrofoil **68** and the tail **70**.

[0019] As shown in FIG. **3**, there is shown a cross sectional view of the hydrofoil **68** and one flap, shown as flap **74** taken along line **3-3** in FIG. **2**. The hydrofoil **68** is seen to have a tapered leading edge **78** and extending rearwardly to the flap **74**. A hinge **80** is configured to allow the flap **74** to articulate with respect to the leading edge **76** of the hydrofoil **68**, and a respective motor **82** (FIG. **4**) is configured to articulate the flap **74** as a function of controller **76**. The leading edge **76** includes a brace member **84** having a laterally extending slot **86** filled with a material **88**, such as a carbon fiber material, positioned between an upper surface **90** of the leading edge **76** and an upper surface **92** of the flap **74** to provide a smooth and continuous surface that prevents drag. The material **88** forms an interface comprising a smooth and planar surface between the lead edge **76** and the respective flap.

[0020] Referring to FIG. **4**, there is shown the control system **76** of the hydrofoil board **10**. The electrical processor **100** has on chip memory including code instructions for controlling the flaps **72** and **74** to automatically stabilize and control the position of the hydrofoil board **10** while propelled above the water. The processor **100** includes an inertial measurement unit (IMU) **102** and a global positioning system (GPS) unit **104**. The processor **100** uses the IMU **102** data to automatically control the hydrofoil board **10** to remain level when in motion, unless turning, regardless of the rider's weight distribution. The processor **100** uses the IMU **102** data to control the hydrofoil board **10** to work even without a rider, referred to as a drone hydrofoil board. The processor **100** controls are complimentary to the received user controls, and in one example the processor **100** controls supersede the user provided controls via wireless controller **50**.

[0021] The IMU **102** is the main sensing unit that conveys orientation and acceleration information to the processor **100**. The GPS unit **104** is also used as an additional speed and location sensor. The processor **100** combines the IMU **102** data with the user/rider's input, such as speed and direction via handheld wireless controller **50**, and individually controls the flap motor(s) **82** to position flaps **72** and **74**, and propulsion motor **46** to set speed accordingly and ensure that the hydrofoil board **10** behaves as intended, such as level forward movement and turning. The processor **100** controls the hydrofoil board **10** to automatically react to even small disturbances from waves. The processor **100** also uses the IMU **102** to automatically bring the hydrofoil board **10** to a smooth and level stop when instructed, which is one of the hardest things to master.

[0022] In an example, the processor **100** continuously monitors the IMU **102** data to determine if the hydrofoil board **10** is level when propelled through the water. If the processor **100** determines, for example, that the hydrofoil board **10** is leaning downward to the left, the processor **100** controls the respective motor **82** to position the left flap **72** downward to create lift on the left side and bring the hydrofoil board **10** back to level. The processor **100** may also, or alternatively, control the respective motor **82** to position the right flap **74** upward to create a downward force. The processor **100** uses a feedback control loop with the IMU **102** to continuously monitor and adjust the position of the hydrofoil board **10** using flaps **72** and **74** during use. Likewise, if the processor **100** determines from the IMU **102** data the hydrofoil board **10** is leaning downward to the right, the processor **100** positions the right flap **74** downward to create lift, and may also, or alternatively position the left flap **72** upward to create a downward force. If the hydrofoil board **10** is determined by processor **100** to be pitched upwardly, the processor **100** controls both motors **82** to position both flaps **72** and **74** downward to each create lift. Likewise, if the hydrofoil board **10** is determined by processor **100** to be pitched downwardly, the processor **100** uses both motors **82** to position both flaps **72** and **74** upward to each create a downward force. The power of the propulsion motor **46** remains constant.

[0023] In an example, when the user uses the handheld controller **50** to select an automatic stop of the hydrofoil board **10**, the processor **100** controls both motors **82** to position both flaps **72** and **74** downward to each create lift, while reducing the power of the propulsion motor **46**. The processor may also individually control the flaps **72** and **74** to adjust for any lateral tilt during the slowdown. The processor **100** monitors the IMU **102** data and dynamically responds to the data to keep the hydrofoil board at a slight upward pitch during the slowdown.

[0024] Referring to FIG. **5**, there is shown a stabilizer algorithm **500** comprising computer readable instructions executable by processor **100** and configured to control the hydrofoil board **10**. The user of the hydrofoil board **10** powers it on, such as by controlling a switch, and positions oneself upon the tip surface **14** of floatable board **12** in the water.

[0025] At block **510**, the user provides user input to processor **100** using wireless controller **50**. The user selects the speed, such as by pressing an up/down button or portion of a touchpad, as well as a direction such as by pressing a left/right button or touchpad on the wireless controller **50**.

[0026] At block **512**, the processor **100** receives the user's instructions from wireless controller **50** via a wireless link. The processor **100** responsively controls the propulsion motor **46** to establish the selected speed. The processor **100** also responsively controls the flaps **72** and **74** to establish the selected direction of the hydrofoil board **10**.

[0027] At block **514**, the processor **100** receives IMU data from IMU **102** and automatically stabilizes the board **12** to be level during forward movement, even when the hydrofoil board **10** encounters small disturbances from waves, and when the user encounters wind that may cause the user to tilt or lose balance. The processor **100** automatically controls and adjusts the speed of the hydrofoil board **10** by controlling the amount of power delivered from battery **42** to propulsion motor **46**, and automatically controls and adjusts the position of each flap **72** and **74** to automatically stabilize the board to be level. The controller **100** also automatically controls the speed and pitch of the board **12** when the user selects the stop feature using wireless controller **50**, such as by pressing a stop button or touchpad. The controller controllable slows the propulsion motor **46** down, and also simultaneously controls each of the flaps **72** and **74** to keep the board **12** stable as the board **12** comes to a complete stop.

[0028] The terms and expressions used herein are understood to have the ordinary meaning as is accorded to such terms and expressions with respect to their corresponding respective areas of inquiry and study except where specific meanings have otherwise been set forth herein. Relational terms such as first and second and the like may be used solely to distinguish one entity or action from another without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms “comprises,” “comprising,” “includes,” “including,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises or includes a list of elements or steps does not include only those elements or steps but may include other elements or steps not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by “a” or “an” does not, without further constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

[0029] The term “coupled” as used herein refers to any logical, optical, physical, or electrical connection, link, or the like by which signals or light produced or supplied by one system element are imparted to another coupled element. Unless described otherwise, coupled elements or devices are not necessarily directly connected to one another and may be separated by intermediate components, elements or communication media that may modify, manipulate, or carry the light or signals.

[0030] In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various examples for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed examples require more features than are expressly recited in each claim. Rather, as the following claims reflect, the subject matter to be protected lies in less than all features of any single disclosed example. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

Claims

1. A hydrofoil board, comprising: a floatable board having a top surface configured to support a user; a strut coupled to the floatable board; a propulsion system coupled to the strut and configured to propel the floatable board in a direction; a hydrofoil coupled to the strut and having a flap configured to stabilize the floatable board when in motion; an inertial measurement unit (IMU); a processor configured to control the propulsion system and the flap; a wireless controller operable by a user and configured to send control signals to control the processor to control the hydrofoil board; and wherein the processor is configured to selectively supersede the control signals provided by the wireless controller such that the wireless controller has limited control of the hydrofoil board.
2. The hydrofoil board as specified in claim 1, wherein the wireless controller is configured to control the flap.
3. The hydrofoil board as specified in claim 1, wherein the hydrofoil board comprises two said flaps.
4. The hydrofoil board as specified in claim 1, wherein the controller is configured to automatically position the floatable board in a level position when in motion.
5. The hydrofoil board as specified in claim 4, wherein the processor in combination with the IMU is configured to automatically stabilize the floatable board when in motion.
6. The hydrofoil board as specified in claim 1, wherein the hydrofoil has a hydrofoil top surface and the flap has a flap top surface, wherein there is a smooth continuous surface between the hydrofoil top surface and the flap top surface.
7. The hydrofoil board as specified in claim 1, further comprising an interface between the flap and the hydrofoil comprising a smooth continuous surface.
8. A method of operating a hydrofoil board including a floatable board having a top surface configured to support a user, a strut coupled to the floatable board, a propulsion system coupled to the strut and configured to propel the floatable board in a direction, a hydrofoil coupled to the strut and having a flap configured to stabilize the floatable board when in motion, an inertial measurement unit (IMU), a processor configured to control the propulsion system and the flap, a wireless controller operable by a user and configured to send control signals to control the processor to control the hydrofoil board, wherein the processor is configured to selectively supersede the control signals provided by the wireless controller, comprising: the processor receiving instructions from the wireless controller to control the propulsion system and the flap; the processor selectively superseding the control signals provided by the wireless controller such that the wireless controller has limited control of the hydrofoil board.
9. The method as specified in claim 8, wherein the wireless controller controls the flap.
10. The method as specified in claim 8, wherein the hydrofoil board comprises two said flaps.
11. The method as specified in claim 8, wherein the processor automatically positions the floatable board in a level position when in motion.
12. The method as specified in claim 11, wherein the processor in combination with the IMU automatically stabilizes the floatable board when in motion.
13. The method as specified in claim 8, wherein the hydrofoil has a hydrofoil top surface and the flap has a flap top surface, wherein there is a smooth continuous surface between the hydrofoil top surface and the flap top surface.

14. The method as specified in claim 8, wherein the hydrofoil board comprises an interface between the flap and the hydrofoil comprising a smooth continuous surface.
15. A non-transitory computer readable medium having computer readable code that when executed by a processor of a hydrofoil board including a floatable board having a top surface configured to support a user, a strut coupled to the floatable board, a propulsion system coupled to the strut and configured to propel the floatable board in a direction, a hydrofoil coupled to the strut and having a flap configured to stabilize the floatable board when in motion, an inertial measurement unit (IMU), the processor configured to control the propulsion system and the flap, a wireless controller operable by a user and configured to send control signals to control the processor to control the hydrofoil board, wherein the processor is configured to selectively supersede the control signals provided by the wireless controller, is operable to: receive instructions from the wireless controller to control the propulsion system and the flap; and selectively superseding the control signals provided by the wireless controller such that the wireless controller has limited control of the hydrofoil board.
16. The non-transitory computer readable medium as specified in claim 15, wherein the wireless controller controls the flap.
17. The non-transitory computer readable medium as specified in claim 15, wherein the hydrofoil board comprises two said flaps.
18. The non-transitory computer readable medium as specified in claim 15, wherein the processor automatically positions the floatable board in a level position when in motion.
19. The non-transitory computer readable medium as specified in claim 18, wherein the processor in combination with the IMU automatically stabilizes the floatable board when in motion.
20. The non-transitory computer readable medium as specified in claim 15, wherein the hydrofoil has a hydrofoil top surface and the flap has a flap top surface, wherein there is a smooth continuous surface between the hydrofoil top surface and the flap top surface.