CLAIMS

[Claim 1] A ship maneuvering system comprising:

a front-rear propulsor that outputs thrust toward both sides in a front-rear direction of a hull;

a lateral propulsor that outputs lateral thrust toward both sides in a lateral direction of the hull;

at least one mooring structure located close to a stern of the hull and at least one mooring structure located close to a bow of the hull, each of the mooring structures being configured to wind and unwind a mooring rope; and

ship maneuvering circuitry configured to control operations of propulsion structures including the front-rear propulsor, the lateral propulsor, and the mooring structures, the mooring structures being regarded as the propulsion structures each of which outputs thrust corresponding to the tension of the mooring rope, wherein

when the hull arrives at and is moored to a quay, the ship maneuvering circuitry performs

arrival maneuver in which the hull is moved from a predetermined arrival start position to a mooring start position closer to the quay than the arrival start position; and

mooring maneuver in which the hull is moved from the mooring start position and is made to reach the quay, and

in the arrival maneuver or the mooring maneuver, the ship maneuvering circuitry

acquires a command vector defined such that a direction and magnitude of the command vector represent a command thrust acting on the hull,

distributes thrust corresponding to the command vector to the propulsion structures, and

controls the propulsion structures such that the propulsion structures output the distributed thrust.

[Claim 2] The ship maneuvering system according to claim 1, wherein the ship maneuvering circuitry distributes the thrust to the propulsion structures such that a thrust vector corresponds to the command vector, the thrust vector being defined such that a direction and magnitude of the thrust vector represent resultant force of the thrust output from the propulsion structures.

[Claim 3] The ship maneuvering system according to claim 1 or 2, further comprising a joystick that receives an operation and inputs the operation to the ship maneuvering circuitry,

wherein:

a tilt angle of the joystick corresponds to magnitude of the command vector;

a tilt direction of the joystick corresponds to a direction of the command vector; and

the ship maneuvering circuitry acquires the command vector corresponding to the operation received by the joystick.

[Claim 4] The ship maneuvering system according to claim 1, further comprising:

a distance meter that measures a hull-quay distance of the hull; and

a ship position measurer that measures a ship position of the hull, wherein

the ship maneuvering circuitry generates the command vector based on the hull-quay distance and the ship position.

[Claim 5] The ship maneuvering system according to any one of claims 1 to 4, wherein

the ship maneuvering circuitry

acquires disturbance information including a wind direction, a wind speed, and a tidal current in an environment around the hull,

estimates disturbance force acting on the hull based on the disturbance information, and

corrects the command vector by the disturbance force.

[Claim 6] The ship maneuvering system according to any one of claims 1 to 5, wherein:

in the arrival maneuver, the ship maneuvering circuitry distributes the thrust to the propulsion structures such that the thrust distributed to the mooring structures becomes zero.

[Claim 7] The ship maneuvering system according to claim 6, wherein in the mooring maneuver, the ship maneuvering circuitry distributes the thrust to the propulsion structures such that among the propulsion structures, the thrust is distributed to the mooring structures more preferentially than the other propulsion structures.

[Claim 8] The ship maneuvering system according to any one of claims 1 to 7, wherein the ship maneuvering circuitry includes a hull kinetic model configured to estimate the thrust output from each mooring structure based on the tension of the mooring rope of the mooring structure.

[Claim 9] A ship maneuvering method of a ship,

the ship comprising:

a front-rear propulsor that outputs thrust toward both sides in a front-rear direction of a hull;

a lateral propulsor that outputs thrust toward both sides in a lateral direction of the hull; and

at least mooring structure located close to a stern of the hull and at least mooring structure located close to a bow of the hull, each of the mooring structures being configured to wind and unwind a mooring rope,

the ship maneuvering method comprising:

when the hull arrives at and is moored to a quay,

performing arrival maneuver in which the hull is moved from a predetermined arrival start position to a mooring start position closer to the quay than the arrival start position

performing mooring maneuver in which the hull is moved from the mooring start position and is made to reach the quay, wherein

in the arrival maneuver or the mooring maneuver, the ship maneuvering method further comprising:

acquiring a command vector defined such that a direction and magnitude of the command vector represent a command thrust acting on the hull;

distributing thrust corresponding to the command vector to propulsion structures including the front-rear propulsor, the lateral propulsor, and the mooring structures, the mooring structures being regarded as the propulsion structures each of which outputs thrust corresponding to tension of the mooring rope; and

controlling the propulsion structures such that the propulsion structures output the distributed thrust.

[Claim 10] The ship maneuvering method according to claim 9, wherein the distributing step includes distributing the thrust to the propulsion structures such that a thrust vector corresponds to the command vector, the thrust vector being defined such that a direction and magnitude of the thrust vector represent resultant force of the thrust output from the propulsion structures.

[Claim 11] The ship maneuvering method according to claim 9 or 10, wherein the step of acquiring the command vector includes acquiring the command vector corresponding to an operation received by a joystick, a tilt angle of the joystick corresponding to magnitude of the

command vector, a tilt direction of the joystick corresponding to a direction of the command vector.

[Claim 12] The ship maneuvering method according to claim 9 or 10, wherein the step of acquiring the command vector includes

measuring a hull-quay distance of the hull,

measuring a ship position of the hull, and

generating the command vector based on the hull-quay distance and the ship position.

[Claim 13] The ship maneuvering method according to any one of claims 9 to 12, wherein the step of acquiring the command vector includes

acquiring disturbance information including a wind direction, a wind speed, and a tidal current in an environment around the hull,

estimating disturbance force acting on the hull based on the disturbance information, and

correcting the command vector by the disturbance force.

[Claim 14] The ship maneuvering method according to any one of claims 9 to 13, wherein

in the arrival maneuver, the thrust is distributed to the propulsion structures such that the thrust distributed to the mooring structures becomes zero.

[Claim 15] The ship maneuvering method according to claim 14, wherein in the mooring maneuver, the thrust is distributed to the propulsion structures such that among the propulsion structures, the thrust is distributed to the mooring structures more preferentially than the other propulsion structures.

[Claim 16] The ship maneuvering method according to any one of claims 9 to 15, wherein the thrust distributed to each mooring structure is determined by using a hull kinetic model configured to estimate the thrust output from the mooring structure based on the tension of the mooring rope of the mooring structure.