Description

Title of Invention: FLIGHT MANAGEMENT APPARATUS, FLYING OBJECT, FLIGHT MANAGEMENT SYSTEM, ~~DISTRIBUTED SYSTEM~~, FLIGHT MANAGEMENT METHOD, FLIGHT CONTROL METHOD AND PROGRAM

Technical Field

[0001] The present disclosure relates to a flight management apparatus, a flying object, a flight management system, a distributed system, a flight management method, a flight control method and a program.

Background Art

[0002] Recently, technologies related to aircraft such as drones and flying cars have been developed. For example, PTL 1 discloses that a route control apparatus can determine a mobile unit's route denoted by blocks, which are divided spaces. In detail, if there is a block common to the movement paths of a plurality of mobile units, the apparatus changes the movement path of one of the mobile units so as not to let the mobile unit to pass through the common block 25 in the same time zone. In this way, the apparatus generates the movement path of the mobile units.

[0003] As other related technology, PTL 2 discloses that when management module receives a reservation request for a destination segment from mobile drive unit, it reserves the segment for the mobile drive unit. Because of this procedure of reservation, the management module prevents the mobile drive units from crashing into each other.

[0004] In addition, PTL 3 discloses that a central station can reserve destination zone for a mobile drive unit and act as a space allocator.

Citation List

Patent Literature

[0005] PTL 1: JP 2019-066381A

PTL 2: US 7,912,574 B2

PTL 3: US 10,591,931 B1

Summary of Invention

Technical Problem

[0006] Flying objects, such as flying cars or drones, could have to turn or make an emergency landing during flight. In such a case, it is desirable to provide a control method for guiding the flying object so that it can maintain a distance from other flying objects and fly safely.

[**CLAIMS**]

[Claim 1]

A flight management apparatus comprising:

a receiving unit configured to receive, from one of a plurality of flying objects, a first request for permission to move to a specific space cell in a space on a flight route of the one flying object determined by the one flying object;

a determination unit configured to determine whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell, when the receiving unit receives the first request; and

a permission unit configured to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is not reserved for another flying object, and not to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is already reserved for another flying object.

[Claim 2]

The flight management apparatus according to Claim 1, further comprising:

a transmission unit configured to transmit, to the one flying object, non-permission information indicating that the permission unit does not permit the movement to the specific space cell of the one flying object when the permission unit does not permit it; and

wherein the determination unit determines whether another space cell in the space other than the specific space cell is already reserved for another flying object based on a reservation state of another space cell, when the receiving unit receives a second request from the one flying object requesting permission to move to another space cell after the transmission unit transmits the non-permission information; and

the permission unit permits the movement to another space cell of the one flying object when the determination unit determines another space cell is not reserved for another flying object, and does not permit the movement to another space cell of the one flying object when the determination unit determines another space cell is already reserved for another flying object.

[Claim 3]

The flight management apparatus according to Claim 1 or 2, further comprising:

a memory configured to store reservation states of the plurality of flying objects related to a plurality of space cells into which the space is divided; and

wherein the flight management apparatus cancels the reservation state of a space cell

related to a third request, being for canceling the reservation of the space cell passed by the one flying object, when the flight management apparatus receives the third request from the one flying object.

[Claim 4]

The flight management apparatus according to any one of Claims 1 to 3, further comprising:

a memory configured to store reservation states of a plurality of space cells into which the space is divided; and

a movement management unit configured to control the plurality of flying objects to fly two-dimensionally in a plane constituted of space cells of the same height to manage the traffic of the plurality of flying objects in the plane.

[Claim 5]

The flight management apparatus according to Claim 4,

wherein the movement management unit permits movement of the plurality of flying objects in a predetermined axial direction in the plane, but does not permit movement in any other direction.

[Claim 6]

The flight management apparatus according to Claim 5,

wherein the movement management unit sets a plurality of lanes for moving the flying objects in the predetermined axial direction in the plane, reference speeds of the flying object being different from each other in the plurality of lanes.

[Claim 7]

The flight management apparatus according to Claim 5,

wherein the movement management unit sets a plurality of lanes for moving the flying objects in the predetermined axial direction in the plane, and determines moving direction of the lanes by using at least one of time information and date information.

[Claim 8]

The flight management apparatus according to any one of Claims 1 to 7, further comprising:

a memory configured to store reservation states of a plurality of space cells into which the space is divided; and

wherein the flight management apparatus can change size of the space cells according to at least one of the locations where the plurality of space cells is located or time information.

[Claim 9]

The flight management apparatus according to any one of Claims 1 to 8, further comprising:

a memory configured to store reservation states of a plurality of space cells into which the space is divided; and

wherein predetermined priority is set to the flying object, and the flight management apparatus permits movement to a predetermined space cell or movement in a predetermined direction from a predetermined space cell to the flying object having high priority, but does not permit the movement to the flying object having low priority.

[Claim 10]

The flight management apparatus according to any one of Claims 1 to 9, further comprising:

a memory configured to store reservation states of a plurality of space cells into which the space is divided; and

wherein the flight management apparatus switches, according to predetermined conditions, whether or not the one flying object can move to a predetermined space cell constituting an area where weather unsuitable for flight has occurred, or to a predetermined space cell in which the density of flying objects in the surrounding space cells is equal to or greater than a threshold value.

~~[Claim 11]~~

~~The flight management apparatus according to any one of Claims 1 to 10, further comprising:~~

~~a memory configured to store reservation states of a plurality of space cells into which the space is divided; and~~

~~wherein the flight management apparatus switches propriety of movement to a space cell above the one flying object according to at least one of real-time data of the one flying object and the state of a driver's license relating to the one flying object.~~

~~[Claim 12]~~

~~The flight management apparatus according to any one of Claims 1 to 11, further comprising:~~

~~a memory configured to store reservation states of a plurality of space cells into which the space is divided; and~~

~~wherein the flight management apparatus reserves an adjacent space cell adjacent to a space cell in which the one flying object is located and permits the one flying object to move to the adjacent space cell, when receiving an emergency request from the one flying~~

~~object.~~

~~[Claim 13]~~

~~The flight management apparatus according to any one of Claims 1 to 12,~~

~~wherein the flight management apparatus sets each space cell dividing the space in the shape of a regular hexagonal column.~~

[Claim 11~~14~~]

A flying object comprising:

a request generation unit configured to determine own flight route and generate a first request for permission to move to a specific space cell on the flight route in a space;

a transmission unit configured to transmit the first request, generated by the request generation unit, to a flight management apparatus; and

a flight control unit configured to move an airframe to the specific space cell when the specific space cell is not reserved by another flying object and the flying object receives permission information permitting movement to the specific space cell from the flight management apparatus, and not to move the airframe to the specific space cell when the specific space cell is already reserved by another flying object and the flying object receives non-permission information not permitting the movement to the specific space cell from the flight management apparatus, wherein

the request generation unit updates the flight route based on the non-permission information received from the flight management apparatus.

[Claim 12~~15~~]

The flying object according to Claim 11~~14~~,

wherein the request generation unit generates a second request for permission to move to another space cell other than the specific space cell, when the flying object receives the non-permission information; and

the transmission unit transmits the second request generated by the request generation unit to the flight management apparatus.

[Claim 13~~16~~]

The flying object according to Claim 12~~15~~,

wherein the request generation unit determines another space cell by using at least one of the positional relationships between a present position and a destination, weather information, a remaining amount of resources necessary for the flight of the flying object, and speed of the flying object.

~~[Claim 17]~~

~~The flying object according to any one of Claims 14 to 16, further comprising:~~

~~a relinquishing unit configured to generating a third request for canceling reservation of a space cell passed by the flying object; and~~

~~wherein the transmission unit transmits the third request generated by the relinquishing unit to the flight management apparatus.~~

~~[Claim 18]~~

~~The flying object according to any one of Claims 14 to 17, further comprising:~~

~~an emergency detection unit configured to detect an emergency situation in the flying object; and~~

~~wherein the request generation unit generates an emergency request for permission to move to an adjacent space cell adjacent to a space cell where the flying object is located, when the emergency detection unit detects the emergency situation; and~~

~~the transmission unit transmits the emergency request generated by the request generation unit to the flight management apparatus.~~

~~[Claim 19]~~

~~The flying object according to any one of Claims 14 to 18,~~

~~wherein the flight control unit moves the airframe along the flight route determined by the request generation unit through the space cell where the movement is permitted by the permission information.~~

[Claim 14~~20~~]

A flight management system comprising:

a plurality of flying objects; and

a flight management apparatus for managing the plurality of flying objects,

wherein each of the plurality of flying objects includes:

a request generation unit configured to determine own flight route and generate a request for permission to move to a specific space cell on the flight route in a space; and

a request transmission unit configured to transmit the request, generated by the request generation unit, to the flight management apparatus, and

wherein the flight management apparatus includes:

a receiving unit configured to receive the request from one of the plurality of flying objects;

a determination unit configured to determine whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell, when the receiving unit receives the request; and

a permission unit configured to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is not reserved for another flying object and not to permit the movement to the specific space cell of the one flying object when the determination unit determines the specific space cell is already reserved for another flying object.

[Claim 15~~21~~]

The flight management system according to Claim 14~~20~~,

wherein the flight management system includes a first and second of the flight management apparatuses,

each of the first and second flight management apparatuses has a memory configured to store reservation states of a plurality of space cells in which a space is divided, and a first and second spaces to which the first and second flight management apparatuses respectively store the reservation state are different spaces, wherein

when the first flight management apparatus recognizes a flying object flying from the second space toward the first space and the receiving unit of the first flight management apparatus receives a request for permission to move to a specific space cell in the first space from the flying object,

the determination unit of the first flight management apparatus determines whether or not the specific space cell is already reserved by another flying object, and

the permission unit of the first flight management apparatus permits movement of the flying object to the specific space cell when the determination unit determines that the specific space cell is not reserved by another flying object, and does not permit movement of the flying object to the specific space cell when the determination unit determines that the specific space cell is already reserved by another flying object.

[Claim 16~~22~~]

The flight management system according to Claim 14~~20~~ or 15~~21~~,

wherein the flight management apparatus further includes a route proposal unit configured to propose a flight route of the flying object when the permission unit permits or rejects the movement to the specific space cell, and

the request generation unit of the flying object determines the flight route by agreeing with all or part of the flight route proposed by the route proposal unit.

~~[Claim 23]~~

~~The flight management system according to any one of Claims 20 to 22,~~

~~wherein each of the plurality of flying objects further includes:~~

a cryptographic processing unit configured to encrypt the position information of the specific space cell related to the request with a public key; and

a flight control unit which controls the flight of each flying object, and

the flight management apparatus further includes: a position information transmission unit configured to transmit, to the flying object, position information of a space cell in which the flying object moves instead of the specific space cell when the permission unit does not permit the flying object to move to the specific space cell,

the request transmission unit of the flying object transmits the request including the encrypted position information of the specific space cell to the flight management apparatus,

in the flight management apparatus, the receiving unit receives the request including the encrypted position information of the specific space cell, and when the determination unit determines, based on the reservation state of the specific space cell indicated by encrypted expression, that the specific space cell is already reserved by another flying object, the permission unit does not permit the moving of the flying object to the specific space cell, and the position information transmission unit transmits, to the flying object, the position information of the space cell in which the flying object moves instead of the specific space cell in an encrypted form, and

the cryptographic processing unit of the flying object decrypts the transmitted position information of the space cell in the encrypted form using a secret key, and the flight control unit moves the flying object to the position indicated by the decrypted position information.

[Claim 24]

A distributed system comprising:

a plurality of flying objects;

wherein each of the plurality of flying objects includes:

a communication unit configured to communicate with other flying objects using a peer-to-peer communication system to form the distributed system including the flying object itself and the other flying objects; and

an adjudication unit configured to cause the communication unit to transmit its own vote with a predetermined weighting for a specific space cell in a space to the other flying objects, and

the adjudication unit of the flying object which transmitted the heaviest weighted vote executes an adjudication of which flying object the specific space cell is to be allocated.

[Claim 25]

The distributed system according to Claim 24,

~~wherein the adjudication unit executes the adjudication using blockchain technology.~~

~~[Claim 26]~~

~~The distributed system according to Claim 24 or 25,~~

~~wherein the adjudication unit determines the predetermined weighting using at least one of a flight route, a traveling direction, distance to the specific space cell, status information, priority, an occupancy status of the specific space cell, or an allocation status of the specific space cell of the flying object.~~

[Claim 17~~27~~]

A flight management method comprising:

receiving, from one of a plurality of flying objects, a request for permission to move to a specific space cell in a space on a flight route of the one flying object determined by the one flying object;

determining whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell; and

permitting the movement to the specific space cell of the one flying object when determining the specific space cell is not reserved for another flying object and not permitting the movement to the specific space cell of the one flying object when determining the specific space cell is already reserved for another flying object.

[Claim 18~~28~~]

A flight control method comprising:

determining own flight route,

generating a request for permission to move to a specific space cell on the flight route in a space;

transmitting the request to a flight management apparatus;

moving an airframe to the specific space cell when the specific space cell is not reserved by another flying object and the flying object receives permission information permitting movement to the specific space cell from the flight management apparatus, and not moving the airframe to the specific space cell when the specific space cell is already reserved by another flying object and the flying object receives non-permission information not permitting the movement to the specific space cell from the flight management apparatus; and

updating the flight route based on the non-permission information received from the flight management apparatus.

[Claim 19~~29~~]

A program for causing a computer to execute:

receiving, from one of a plurality of flying objects, a request for permission to move to a specific space cell in a space on a flight route of the one flying object determined by the one flying object;

determining whether the specific space cell is already reserved for another flying object of the plurality of flying objects based on a reservation state about the specific space cell; and

permitting the movement to the specific space cell of the one flying object when determining the specific space cell is not reserved for another flying object and not permitting the movement to the specific space cell of the one flying object when determining the specific space cell is already reserved for another flying object.

[Claim 20~~30~~]

A program for causing a computer to execute:

determining own flight route,

generating a request for permission to move to a specific space cell on the flight route in a space;

transmitting the request to a flight management apparatus;

moving an airframe to the specific space cell when the specific space cell is not reserved by another flying object and receiving permission information permitting movement to the specific space cell from the flight management apparatus, and not moving the airframe to the specific space cell when the specific space cell is already reserved by another flying object and receiving non-permission information not permitting the movement to the specific space cell from the flight management apparatus; and

updating the flight route based on the non-permission information received from the flight management apparatus.