SUMMARY

[0006] The illustrative embodiments of the present disclosure provide a method of turning an aircraft for interval management. Interval management information identifying a desired spacing between the aircraft and a target aircraft is received. Turn information is determined using a performance gain factor. The turn information identifies a turn point for the aircraft. The performance gain factor identifies a desired portion of achieving the desired spacing due to turning the aircraft at the turn point and a desired portion of achieving the desired spacing due to changing speed of the aircraft. Determining the turn information comprises determining a search goal using the performance gain factor; selecting a candidate turn point along a leg of flight of the aircraft; evaluating the candidate turn point to determine whether the candidate turn point satisfies the search goal; and identifying the candidate turn point as the turn point in response to a determination that the candidate turn point satisfies the search goal. The turn information is used to turn the aircraft at the turn point.

[0007] The illustrative embodiments of the present disclosure also provide an apparatus comprising an information receiver, a turn calculator, and an information formatter. The information receiver is configured to receive interval management information identifying a desired spacing between an aircraft and a target aircraft. The turn calculator is configured to determine turn information using a performance gain factor. The turn information identifies a turn point for the aircraft. The performance gain factor identifies a desired portion of achieving the desired spacing due to

turning the aircraft at the turn point and a desired portion of achieving the desired spacing due to changing speed of the aircraft. The turn calculator comprises a search goal determiner configured to determine a search goal using the performance gain factor; a point selector configured to select a candidate turn point along a leg of flight of the aircraft; and a turn point evaluator configured to evaluate the candidate turn point to determine whether the candidate turn point satisfies the search goal and to identify the candidate turn point as the turn point in response to a determination that the candidate turn point satisfies the search goal. The information formatter is configured to format the turn information for using the turn information to turn the aircraft at the turn point.

[0008] The illustrative embodiments of the present disclosure also provide a method of turning an aircraft for interval management. A search goal is determined

using a desired spacing between the aircraft and a target aircraft. The search goal uses a performance gain factor, wherein the performance gain factor identifies a desired portion of achieving the desired spacing between the aircraft and the target aircraft due to turning the aircraft at the turn point and a desired portion of achieving the desired spacing due to changing speed of the aircraft. A candidate turn point along a leg of flight of the aircraft is selected. The candidate turn point is evaluated to determine whether the candidate turn point satisfies the search goal. The candidate turn point is identified as the turn point in response to a determination that the candidate turn point satisfies the search goal. The aircraft is turned at the turn point.

[0009] Various features, functions, and benefits may be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

CLAIMS:

What is claimed is:

1. A method of turning an aircraft for interval management, comprising:

receiving interval management information identifying a desired spacing between the aircraft and a target aircraft;

determining turn information using a performance gain factor, wherein the turn information identifies a turn point for the aircraft and the performance gain factor identifies a desired portion of achieving the desired spacing due to turning the aircraft at the turn point and a desired portion of achieving the desired spacing due to changing speed of the aircraft;

wherein determining the turn information comprises:

determining a search goal using the performance gain factor;

selecting a candidate turn point along a leg of flight of the aircraft;

evaluating the candidate turn point to determine whether the candidate turn point satisfies the search goal; and

identifying the candidate turn point as the turn point in response to a determination that the candidate turn point satisfies the search goal; and

using the turn information to turn the aircraft at the turn point.

2. The method of claim 1, wherein the performance gain factor identifies a desired portion of a time for achieving the desired spacing between the aircraft and the target aircraft due to turning the aircraft at the turn point and a desired portion of the time for achieving the desired spacing due to changing speed of the aircraft.

3. The method of claim 1, wherein determining the search goal comprises:

determining an estimated time of arrival of the target aircraft at an achieve-by point; and

multiplying a sum of the desired spacing and the estimated time of arrival of the target aircraft at the achieve-by point by the performance gain factor.

4. The method of claim 1, wherein selecting the candidate turn point along the leg of flight of the aircraft comprises:

selecting a first candidate turn point at a minimum distance from a current position of the aircraft along the leg of flight of the aircraft;

determining a second candidate turn point at a maximum distance from the current position of the aircraft along the leg of flight of the aircraft using a maximum turn angle for the aircraft; and

selecting the candidate turn point along the leg of flight of the aircraft between the first candidate turn point and the second candidate turn point.

5. The method of claim 1, wherein selecting the candidate turn point along the leg of flight of the aircraft comprises using an Eulerian method to select the candidate turn point.

6. The method of claim 1, wherein evaluating the candidate turn point comprises:

determining a first predicted spacing between the aircraft and the target aircraft at an achieve-by point assuming that the aircraft turns at the candidate turn point; and

determining that the candidate turn point satisfies the search goal in response to a determination that a difference between the first predicted spacing and the search goal is less than a first threshold value.

7. The method of claim 6, wherein evaluating the candidate turn point further comprises:

determining a second predicted spacing between the aircraft and the target aircraft at an intercept point assuming that the aircraft turns at the candidate turn point; and

determining that the candidate turn point satisfies the search goal in response to a determination that a difference between the second predicted spacing and the desired spacing is less than a second threshold value.

8. The method of any one of claims 1 to 7, wherein using the turn information to turn the aircraft at the turn point comprises at least one of:

displaying the turn information to an operator of the aircraft for manually turning the aircraft by the operator using the turn information;

manually entering the turn information into a flight management system for the aircraft; and

automatically providing the turn information to the flight management system in a format for use by the flight management system to turn the aircraft by the flight management system.

9. An apparatus, comprising:

an information receiver configured to receive interval management information identifying a desired spacing between an aircraft and a target aircraft;

a turn calculator configured to determine turn information using a performance gain factor, wherein the turn information identifies a turn point for the aircraft and the performance gain factor identifies a desired portion of achieving the desired spacing due to turning the aircraft at the turn point and a desired portion of achieving the desired spacing due to changing speed of the aircraft; wherein the turn calculator comprises:

a search goal determiner configured to determine a search goal using the performance gain factor;

a point selector configured to select a candidate turn point along a leg of flight of the aircraft; and

a turn point evaluator configured to evaluate the candidate turn point to determine whether the candidate turn point satisfies the search goal and to identify the candidate turn point as the turn point in response to a determination that the candidate turn point satisfies the search goal; and

an information formatter configured to format the turn information for using the turn information to turn the aircraft at the turn point.

10. The apparatus of claim 9, wherein the performance gain factor identifies a desired portion of a time for achieving the desired spacing between the aircraft and the target aircraft due to turning the aircraft at the turn point and a desired portion of the time for achieving the desired spacing due to changing speed of the aircraft.

11. The apparatus of claim 9, wherein the search goal determiner is configured to:

determine an estimated time of arrival of the target aircraft at an achieve-by point; and

multiply a sum of the desired spacing and the estimated time of arrival of the target aircraft at the achieve-by point by the performance gain factor to determine the search goal.

12. The apparatus of claim 9, wherein the point selector is configured to:

select a first candidate turn point at a minimum distance from a current position of the aircraft along the leg of flight of the aircraft;

determine a second candidate turn point at a maximum distance from the current position of the aircraft along the leg of flight of the aircraft using a maximum turn angle for the aircraft; and

select the candidate turn point along the leg of flight of the aircraft between the first candidate turn point and the second candidate turn point.

13. The apparatus of claim 9, wherein the point selector is configured to use an Eulerian method to select the candidate turn point along the leg of flight of the aircraft.

14. The apparatus of claim 9, wherein the turn point evaluator is configured to:

determine a first predicted spacing between the aircraft and the target aircraft at an achieve-by point assuming that the aircraft turns at the candidate turn point; and

determine that the candidate turn point satisfies the search goal in response to a determination that a difference between the first predicted spacing and the search goal is less than a first threshold value.

15. The apparatus of claim 14, wherein the turn point evaluator is further configured to:

determine a second predicted spacing between the aircraft and the target aircraft at an intercept point assuming that the aircraft turns at the candidate turn point; and

determine that the candidate turn point satisfies the search goal in response to a determination that a difference between the second predicted spacing and the desired spacing is less than a second threshold value.

16. The apparatus of any one of claims 9 to 15, wherein the information formatter is configured to format the turn information for at least one of:

displaying the turn information to an operator of the aircraft for manually turning the aircraft at the turn point by the operator; and

using the turn information by a flight management system on the aircraft to turn the aircraft at the turn point by the flight management system.

17. A method of turning an aircraft for interval management, comprising:

determining a search goal using a desired spacing between the aircraft and a target aircraft wherein the search goal uses a performance gain factor, wherein the

performance gain factor identifies a desired portion of achieving the desired spacing between the aircraft and the target aircraft due to turning the aircraft at the turn point and a desired portion of achieving the desired spacing due to changing speed of the aircraft;

selecting a candidate turn point along a leg of flight of the aircraft;

evaluating the candidate turn point to determine whether the candidate turn point satisfies the search goal;

identifying the candidate turn point as a turn point for the aircraft in response to a determination that the candidate turn point satisfies the search goal; and

turning the aircraft at the turn point.