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(71) Applicant: UNITECH RESEARCH, INC. [US/US]; 3802 Packers Avenue, Madison, WI 53704 (US).

(72) Inventors: WYSOCKI, David, A. ; 4315 County Highway F, Blue Mounds, WI 53517 (US). HOOPER, Paul, S. ; 1904 Barber Drive, Stoughton, WI 53589 (US).

(74) Agent: WELCH, Teresa, J.; Suite 300, 25 West Main Street, P.O. Box 2236, Madison, WI 53701-2236 (US).

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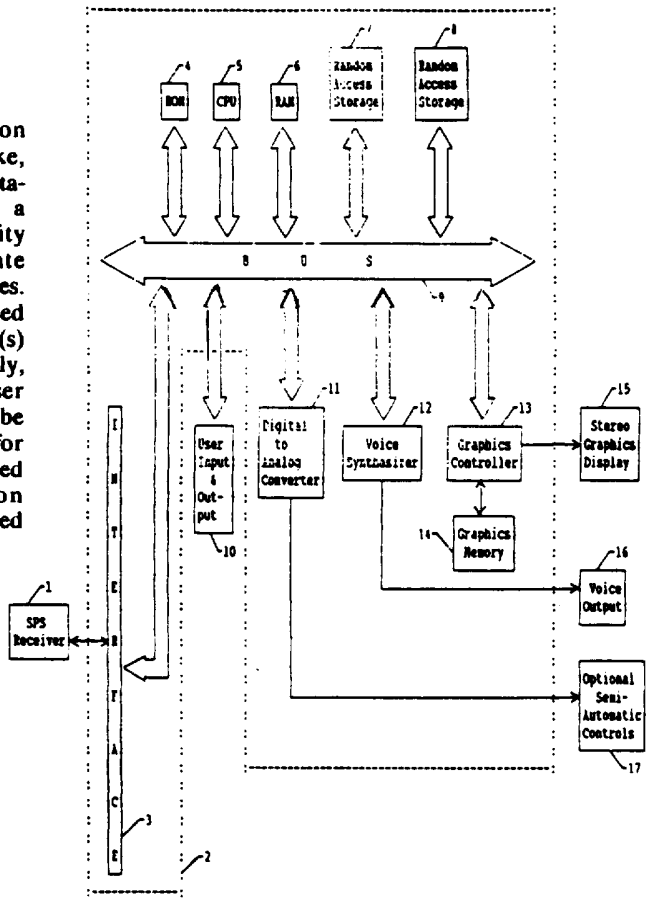
(54) Title: REAL TIME THREE DIMENSIONAL GEO-REFERENCED DIGITAL ORTHOPHOTOGRAPH-BASED POSITIONING, NAVIGATION, COLLISION AVOIDANCE AND DECISION SUPPORT SYSTEM

(57) Abstract

Herein is presented a positioning, navigation and collision avoidance system for ships, aircraft, land vehicles and the like, which utilizes a geo-referenced digital orthophotograph database (6) and a positioning signal (1) to display upon a computer stereo graphics device (15) a high visibility dynamic photographic image of the user's immediate environment, including both moving and stationary obstacles. The position and temporal data along with the geo-referenced elevation data utilized to derive the digital orthophotograph(s) can serve to warn the user of nearby obstacles; and optionally, to implement semi-automatic avoidance. Substituting user generated x-y-z positions and times (10), the system may be used in a static mode as a flight simulator or a simulator for other modes of transportation,. The system may also be used as a molible Geographic Information Systems decision making tool with the addition of user supplied geo-referenced digital data layers.



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AMENDED CLAIMS

[received by the International Bureau on 22 February 1993 (22.02.93);
original claims 1-50 replaced by amended claims 1-28 (5 pages)]

1. A position tracking, navigational, collision-avoidance, and decision support system, comprising;

positioning means for providing positional coordinate signals corresponding to spatial coordinates of a vehicle's position;

computational means for accessing an image library of differentially rectified images of predefined geographic areas, indexed by spatial coordinates, and a data library of terrain elevational data of same said predefined geographic areas, indexed by spatial coordinates; for receiving said positional coordinate signals; and for analyzing said positional coordinate signals by selecting differentially rectified images from said image library and terrain elevational data from said data library, and processing said positional coordinate signals, said selected differentially rectified images, and said terrain elevational data into resultant differentially rectified image signals corresponding to the current position and terrain of said vehicle; and

display means responsive to said resultant differentially rectified image signals for translating said resultant differentially rectified signals into visual, pictorial information corresponding to the geographic surroundings of said vehicle.

2. A method of tracking, navigating, and collision-avoidance of a vehicle, comprising:

obtaining positional coordinate signals corresponding to spatial coordinates of a vehicle's position;

accessing an image library of differentially rectified images of predefined geographic areas, indexed by spatial coordinates, and a data library of terrain elevational data of same said predefined geographic areas, indexed by spatial coordinates;

analyzing said positional coordinate signals by selecting differentially rectified images from said image library and terrain elevational data from said data library;

processing said positional coordinate signals, said selected differentially rectified images, and said terrain elevational data into resultant differentially rectified image signals corresponding to the current position and terrain of the vehicle; and

translating said resultant differentially rectified signals into visual, pictorial information corresponding to the geographic surroundings of said vehicle.

3. The system of claim 1, wherein said positional coordinate signals are derived from a positioning system.

4. The system of claim 1, wherein said vehicle is a ship, aircraft, or land vehicle.

5. The system of claim 1, wherein said positional coordinate signals further include orientation signals corresponding to the pitch, roll and yaw of said vehicle.

6. The system of claim 1, wherein said spatial coordinates are three dimensional, geo-referenced coordinates.

7. The system of claim 1, wherein said image library of differentially rectified images is derived from said data library of terrain elevational data.

8. The system of claim 1, wherein said differentially rectified images are digital orthophotographs.

9. The system of claim 1, further comprising means for generating vehicle signals corresponding to structural vehicle parameters, and said computational means includes means for receiving said vehicle signals and for analyzing said vehicle signals, to provide a spatial representation of said vehicle.

10. The system of claim 1, wherein said positioning means is operatively coupled to timing means for providing timing signals corresponding to the temporal coordinates of said vehicle's position.

11. The system of claim 10, wherein said computational means further comprises means for storing said positional coordinate signals and said timing signals of said vehicle's position.

12. The system of claim 1, wherein said positioning means is operatively coupled to transmitting means for broadcasting said positional coordinate signals to vehicles and structures external to said vehicle, and is operatively coupled to receiving means for intercepting broadcast position data corresponding to spatial coordinates of vehicles and structures external to said vehicle.

13. The system of claim 12, wherein said computational means further comprises means for storing said broadcast position data intercepted by said receiver.

14. The system of claim 12, wherein said computational means further comprises means, responsive to said broadcast position data intercepted by said receiver, for calculating a distance and rate of approach between said vehicle and another vehicle or structure external to said vehicle.

15. The system of claim 14, further comprising means, responsive to said means for calculating a distance and rate of approach between said vehicle and another vehicle or structure, for issuing warning signals corresponding to a predetermined distance and rate of approach between said vehicle and said another vehicle or structure.

16. The system of claim 14, further comprising means, responsive to said means for calculating a distance and rate of approach between said vehicle and said another vehicle or structure, for issuing semi-automatic evasion signals corresponding to a predetermined distance and rate of approach between said vehicle and said another vehicle or structure.

17. The system of claim 1, wherein said computational means further comprises means for calculating a distance and rate of approach between said vehicle and an obstacle, by interrogating said terrain elevational data using said positional coordinate signals.

18. The system of claim 17, further comprising means, responsive to said means for calculating a distance and rate of approach between said vehicle and an obstacle, for issuing

warning signals corresponding to a predetermined distance and rate of approach between said vehicle and said obstacle.

19. The system of claim 17, further comprising means, responsive to said means for calculating a distance and rate of approach between said vehicle and an obstacle, for issuing semi-automatic evasion signals corresponding to a predetermined distance and rate of approach between said vehicle and said obstacle.

20. The system of claim 1, wherein said computational means further comprises means, responsive to said terrain elevational data and said resultant differentially rectified image signals, for generating perspective views of said visual, pictorial information corresponding to the geographic surroundings of said vehicle.

21. The system of claim 1, wherein said data library of terrain elevational data, further comprises three dimensional structure data corresponding to digitized man-made structures.

22. The system of claim 1, wherein said computational means further comprises means for accessing a thematic library of thematic data layers corresponding to various predetermined geographic thematic relationships of same said predefined geographic areas, indexed by geo-referenced spatial coordinates; and for analyzing said positional coordinate signals by selecting differentially rectified images from said image library and terrain elevational data from said data library, and thematic data layers from said thematic library, and processing said positional coordinate signals, said selected differentially rectified images, said terrain elevational data, and said thematic data layers into resultant differentially rectified image signals corresponding to the current position and terrain of the vehicle.

23. The system of claim 22, wherein said computational means further comprises geographic information system means, for analyzing said positional coordinate signals by selecting differentially rectified images from said image library, terrain elevational data from said data library, and thematic data layers

from said thematic library, and processing said positional coordinate signals, said selected differentially rectified images, said terrain elevational data, and said thematic data layers into resultant differentially rectified image signals corresponding to the current position and terrain of the vehicle.

24. The system of claim 1, further comprising a user input coupled to said computational means for providing means for entering control signals corresponding to input parameters representing predefined system functions, system outputs and vehicle characteristics.

25. The system of claim 1, wherein said image library of said differentially rectified images further comprises differentially rectified images of differing scales, and wherein said data library of said terrain elevational data further comprises terrain elevational data of differing spatial resolutions.

26. The system of claim 1, wherein said vehicle is a training simulator or video game.

27. The system of claim 26, wherein said positional coordinate signals are derived via said computational means.

28. The system of claim 1, wherein said differentially rectified images are derived from electronic imaging means.