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(54) METHOD AND SYSTEM FOR DETERMING VISUAL APPROACH GUIDANCE FOR AN AIRCRAFT

(57) A method and system for determining visual approach guidance for an aircraft has been developed. As an aircraft approaches an airport for landing, a visual approach (VA) engine is enabled with an approach path monitor (APM) located onboard the aircraft. An approach path database is accessed that contains multiple visual circling approach paths along with accompanying data for each of the visual circling approach paths. A specific visual circling approach path is selected from the approach path database based on the accompanying data for each of the visual circling approach paths and the aircraft enters the selected specific visual circling approach path.

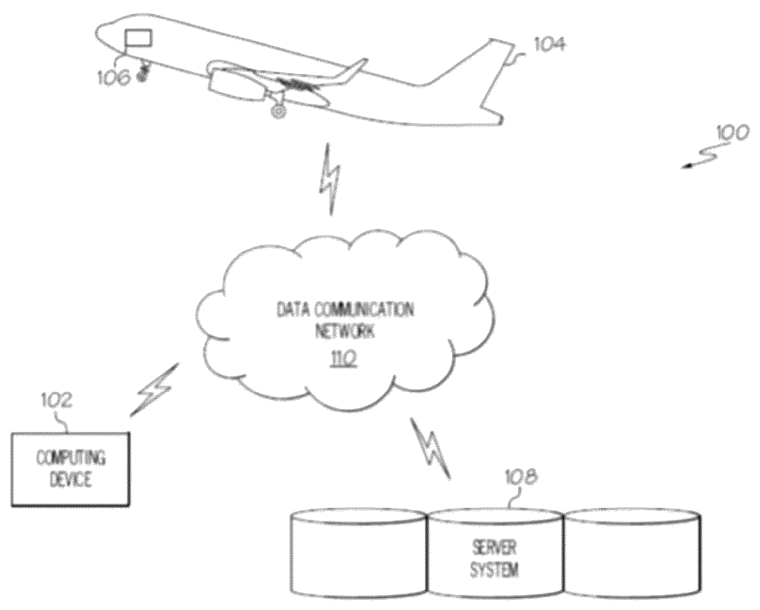

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention generally relates to flight path planning, and more particularly relates to a method and system for determining visual approach guidance for an aircraft.

BACKGROUND

[0002] Visual approaches constitute the majority of all landing approaches for an aircraft as well as the last add-on step to many instrument approaches. Most day-to-day approaches are visual that are either as a blend of instrument procedures and visual pattern segments or entirely "cleared visual approach" procedures. These approaches may have substantial maneuvering prior to a final visual approach path interception. Hence, there is a need for a method and system for determining visual approach guidance for an aircraft.

BRIEF SUMMARY

[0003] This summary is provided to describe select concepts in a simplified form that are further described in the Detailed Description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0004] A method is provided for determining visual approach guidance for an aircraft. The method comprises: approaching an airport in an aircraft for landing; enabling a visual approach (VA) engine with an approach path monitor (APM) located onboard the aircraft; accessing an approach path database that contains multiple visual circling approach paths and accompanying data for each of the visual circling approach paths; selecting a specific visual circling approach path from the approach path database, where the specific visual circling approach is selected based on the accompanying data for each of the visual circling approach paths; and entering the selected specific visual circling approach path.

[0005] A system is provided for determining visual approach guidance for an aircraft. The system comprises: an aircraft control system comprising a visual approach (VA) engine that is enabled with an approach path monitor (APM) as the aircraft approaches an airport for landing; an approach path database that contains multiple visual circling approach paths and accompanying data for each of the visual circling approach paths, where the VA engine selects a specific visual circling approach path from the approach path database based on the accompanying data for each of the visual circling approach paths; and a display unit that displays the selected visual circling approach path to a pilot of the aircraft.

[0006] A method is provided for determining visual approach guidance for an aircraft based on historical patterns. The system comprises: approaching an airport in an aircraft for landing; enabling a visual approach (VA) engine with an approach path monitor (APM) located onboard the aircraft; capturing a VA path and accompanying data until the landing is successfully completed, where the VA path and accompanying data are captured with the VA engine; storing the VA path and accompanying data in a database; factoring each stored VA path within the database based on the number of successful landings using a specific VA path; and ranking each stored VA path within the database based the factoring of each stored VA path.

[0007] Furthermore, other desirable features and characteristics of the disclosed embodiments will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the preceding background.

BRIEF DESCRIPTION OF DRAWINGS

[0008] The present disclosure will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and wherein:

FIG. 1 is a diagram of aircraft computer system in accordance with the disclosed embodiments;

FIG. 2 is a diagram of a vehicle system that includes a display system in accordance with the disclosed embodiments;

FIG. 3 is a block diagram of visual approach path storage and processing in accordance with the disclosed embodiments;

FIG.4 is image of a display system screen with a selected visual approach (VA) path in accordance with the disclosed embodiments;

FIG. 5 is a display of a visual circling approach path in accordance with the disclosed embodiments; and

FIG. 6 is a flow chart of a method for determining visual approach guidance for an aircraft in accordance with the disclosed embodiments.

DETAILED DESCRIPTION

[0009] The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. As used herein, the word "exemplary" means "serving as an example, instance, or illustration." Thus, any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. All of the embodiments described herein are exemplary embodiments provided to enable persons skilled in the art to make or use the invention and not to limit the scope of the invention which is defined by the claims. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary, or the following detailed description.

[0010] A method and system for determining visual approach guidance for an aircraft has been developed. As an aircraft approaches an airport for landing, a visual approach (VA) engine is enabled with an approach path monitor (APM) located onboard the aircraft. An approach path database is accessed that contains multiple visual circling approach paths along with accompanying data for each of the visual circling approach paths. A specific visual circling approach path is selected from the approach path database based on the accompanying data for each of the visual circling approach paths and the aircraft enters the selected specific visual circling approach path.

[0011] Turning now to the figures, FIG. 1 is a diagram of aircraft computer system 100, in accordance with the disclosed embodiments. The computing device 102 may be implemented by any computing device that includes at least one processor, some form of memory hardware, a user interface, and communication hardware. For example, the computing device 102 may be implemented using a personal computing device, such as a tablet computer, a laptop computer, a personal digital assistant (PDA), a smartphone, or the like. In this scenario, the computing device 102 is capable of storing, maintaining, and executing Electronic Flight Bag (EFB) applications. In other embodiments, the computing device 102 may be implemented using a computer system onboard the aircraft 104.

[0012] The aircraft 104 may be implemented as an airplane, helicopter, spacecraft, hovercraft, or the like. The one or more avionics systems 106 may include a Flight Management System (FMS), navigation devices, weather detection devices, radar devices, communication devices, brake systems, and/or any other electronic system or avionics system used to operate the aircraft 104. Data obtained from the one or more avionics systems 106 may include, without limitation: flight data, aircraft heading, aircraft speed, aircraft position, altitude, descent rate, position of air spaces surrounding a current flight plan, activity of air spaces surrounding a current flight plan, or the like.

[0013] The server system 108 may include any number of application servers, and each server may be implemented using any suitable computer. In some embodiments, the server system 108 includes one or more dedicated computers. In some embodiments, the server system 108 includes one or more computers carrying out other functionality in addition to server operations. The server system 108 may store and provide any type of data. Such data may include, without limitation: flight plan data, aircraft parameters, avionics data and associated user actions, and other data compatible with the computing device 200.

[0014] The computing device 102 is usually located onboard the aircraft 104, and the computing device 102 communicates with the one or more avionics systems 106 via wired and/or wireless communication connection. The computing device 102 and the server system 108 may both be located onboard the aircraft 104. In other embodiments, the computing device 102 and the server system 108 may be disparately located, and the computing device 102 communicates with the server system 108 via the data communication network 110 and/or via communication mechanisms onboard the aircraft 104.

[0015] The data communication network 110 may be any digital or other communications network capable of transmitting messages or data between devices, systems, or components. In certain embodiments, the data communication network 110 includes a packet switched network that facilitates packet-based data communication, addressing, and data routing. The packet switched network could be, for example, a wide area network, the Internet, or the like. In various embodiments, the data communication network 110 includes any number of public or private data connections, links or network connections supporting any number of communications protocols. The data communication network 110 may include the Internet, for example, or any other network based upon TCP/IP or other conventional protocols. In various embodiments, the data communication network 110 could also incorporate a wireless and/or wired telephone network, such as a cellular communications network for communicating with mobile phones, personal digital assistants, and/or the like. The data communication network 110 may also incorporate any sort of wireless or wired local and/or personal area networks, such as one or more IEEE 802.3, IEEE 802.16, and/or IEEE 802.11 networks, and/or networks that implement a short range (e.g., Bluetooth) protocol. For the sake of brevity, conventional techniques related to data transmission, signaling, network control, and other functional aspects of the systems (and the individual operating components of the systems) may not be described in detail herein.

[0016] The FMS, as is generally known, is a specialized computer that automates a variety of in-flight tasks such as in-flight management of the flight plan. Using various sensors such as global positioning system (GPS), the FMS determines the aircraft's position and guides the aircraft along its flight plan using its navigation database. From the cockpit, the FMS is normally controlled through a visual display device such as a control display unit (CDU) which incorporates a small screen, a keyboard or a touchscreen. The FMS displays the flight plan and other critical flight data to the aircrew during operation.

[0017] The FMS may have a built-in electronic memory system that contains a navigation database. The navigation database contains elements used for constructing a flight plan. In some embodiments, the navigation database may be separate from the FMS and located onboard the aircraft while in other embodiments the navigation database may be located on the ground and relevant data provided to the FMS via a communications link with a ground station. The navigation database used by the FMS may typically include: waypoints/intersections; airways; radio navigation aids/navigation beacons; airports; runway; standard instrument departure (SID) information; standard terminal arrival (STAR) information; holding patterns; and instrument approach procedures. Additionally, other waypoints may also be manually defined by pilots along the route.

[0018] The flight plan is generally determined on the ground before departure by either the pilot or a dispatcher for the owner of the aircraft. It may be manually entered into the FMS or selected from a library of common routes. In other embodiments the flight plan may be loaded via a communications data link from an airline dispatch center. During preflight planning, additional relevant aircraft performance data may be entered including information such as: gross aircraft weight; fuel weight and the center of gravity of the aircraft. The aircrew may use the FMS to modify the plight flight plan before takeoff or even while in flight for variety of reasons. Such changes may be entered via the CDU. Once in flight, the principal task of the FMS is to accurately monitor the aircraft's position. This may use a GPS, a VHF omnidirectional range (VOR) system, or other similar sensor in order to determine and validate the aircraft's exact position. The FMS constantly cross checks among various sensors to determine the aircraft's position with accuracy.

[0019] Additionally, the FMS may be used to perform advanced vertical navigation (VNAV) functions. The purpose of VNAV is to predict and optimize the vertical path of the aircraft. The FMS provides guidance that includes control of the pitch axis and of the throttle of the aircraft. In order to accomplish these tasks, the FMS has detailed flight and engine model data of the aircraft. Using this information, the FMS may build a predicted vertical descent path for the aircraft. A correct and accurate implementation of VNAV has significant advantages in fuel savings and on-time efficiency.

[0020] Turning now to FIG. 2, in the depicted embodiment, the vehicle control system 202 includes: the control module 204 that is operationally coupled to a communication system 206, an imaging system 208, a navigation system 210, a user input device 212, a display system 214, and a graphics system 216. The operation of these functional blocks is described in more detail below. In the described embodiments, the depicted vehicle system 202 is generally realized as an aircraft flight deck display system within a vehicle 200 that is an aircraft; however, the concepts presented here can be deployed in a variety of mobile platforms, such as land vehicles, spacecraft, watercraft, and the like. Accordingly, in various embodiments, the vehicle system 202 may be associated with or form part of larger aircraft management system, such as a flight management system (FMS).

[0021] In the illustrated embodiment, the control module 204 is coupled to the communications system 206, which is configured to support communications between external data source(s) 220 and the aircraft. External source(s) 220 may comprise air traffic control (ATC), or other suitable command centers and ground locations. Data received from the external source(s) 220 includes the instantaneous, or current, visibility report associated with a target landing location or identified runway. In this regard, the communications system 206 may be realized using a radio communication system or another suitable data link system.

[0022] The imaging system 208 is configured to use sensing devices to generate video or still images, and provide image data therefrom. The imaging system 208 may comprise one or more sensing devices, such as cameras, each with an associated sensing method. Accordingly, the video or still images generated by the imaging system 208 may be referred to herein as generated images, sensor images, or sensed images, and the image data may be referred to as sensed data. In an embodiment, the imaging system 208 comprises an infrared ("IR") based video camera, low-light TV camera, or a millimeter wave (MMW) video camera. The IR camera senses infrared radiation to create an image in a manner that is similar to an optical camera sensing visible light to create an image. In another embodiment, the imaging system 208 comprises a radar based video camera system. Radar based systems emit pulses of electromagnetic radiation and listen for, or sense, associated return echoes. The radar system may generate an image or video based upon the sensed echoes. In another embodiment, the imaging system 208 may comprise a sonar system. The imaging system 208 uses methods other than visible light to generate images, and the sensing devices within the imaging system 208 are much more sensitive than a human eye. Consequently, the generated images may comprise objects, such as mountains, buildings, or ground objects, that a pilot might not otherwise see due to low visibility conditions.

[0023] In various embodiments, the imaging system 208 may be mounted in or near the nose of the aircraft (vehicle 200) and calibrated to align an imaging region with a viewing region of a primary flight display (PFD) or a Head Up display (HUD) rendered on the display system 214. For example, the imaging system 208 may be configured so that a geometric center of its field of view (FOV) is aligned with or otherwise corresponds to the geometric center of the viewing region on the display system 214. In this regard, the imaging system 208 may be oriented or otherwise directed substantially parallel to an anticipated line-of-sight for a pilot and/or crew member in the cockpit of the aircraft to effectively capture a forward looking cockpit view in the respective displayed image. In some embodiments, the displayed images on the display system 214 are three dimensional, and the imaging system

208 generates a synthetic perspective view of terrain in front of the aircraft. The synthetic perspective view of terrain in front of the aircraft is generated to match the direct out-the-window view of a crew member, and may be based on the current position, attitude, and pointing information received from a navigation system 210, or other aircraft and/or flight management systems.

[0024] Navigation system 210 is configured to provide real-time navigational data and/or information regarding operation of the aircraft. The navigation system 210 may be realized as a global positioning system (GPS), inertial reference system (IRS), or a radio-based navigation system (e.g., VHF omni-directional radio range (VOR) or long range aid to navigation (LORAN)), and may include one or more navigational radios or other sensors suitably configured to support operation of the navigation system 210, as will be appreciated in the art. The navigation system 210 is capable of obtaining and/or determining the current or instantaneous position and location information of the aircraft (e.g., the current latitude and longitude) and the current altitude or above ground level for the aircraft. Additionally, in an exemplary embodiment, the navigation system 210 includes inertial reference sensors capable of obtaining or otherwise determining the attitude or orientation (e.g., the pitch, roll, and yaw, heading) of the aircraft relative to earth.

[0025] The user input device 212 is coupled to the control module 204, and the user input device 212 and the control module 204 are cooperatively configured to allow a user (e.g., a pilot, co-pilot, or crew member) to interact with the display system 214 and/or other elements of the vehicle system 202 in a conventional manner. The user input device 212 may include any one, or combination, of various known user input device devices including, but not limited to: a touch sensitive screen; a cursor control device (CCD) (not shown), such as a mouse, a trackball, or joystick; a keyboard; one or more buttons, switches, or knobs; a voice input system; and a gesture recognition system. In embodiments using a touch sensitive screen, the user input device 212 may be integrated with a display device. Non-limiting examples of uses for the user input device 212 include: entering values for stored variables 264, loading or updating instructions and applications 260, and loading and updating the contents of the database 256, each described in more detail below.

[0026] The generated images from the imaging system 208 are provided to the control module 204 in the form of image data. The control module 204 is configured to receive the image data and convert and render the image data into display commands that command and control the renderings of the display system 214. This conversion and rendering may be performed, at least in part, by the graphics system 216. In some embodiments, the graphics system 216 may be integrated within the control module 204; in other embodiments, the graphics system 216 may be integrated within the display system 214. Regardless of the state of integration of these subsystems, responsive to receiving display commands from the control module 204, the display system 214 displays, renders, or otherwise conveys one or more graphical representations or displayed images based on the image data (i.e., sensor based images) and associated with operation of the vehicle 200, as described in greater detail below. In various embodiments, images displayed on the display system 214 may also be responsive to processed user input that was received via a user input device 212.

[0027] In general, the display system 214 may include any device or apparatus suitable for displaying flight information or other data associated with operation of the aircraft in a format viewable by a user. Display methods include various types of computer generated symbols, text, and graphic information representing, for example, pitch, heading, flight path, airspeed, altitude, runway information, waypoints, targets, obstacle, terrain, and required navigation performance (RNP) data in an integrated, multi-color or monochrome form. In practice, the display system 214 may be part of, or include, a primary flight display (PFD) system, a panel-mounted head down display (HDD), a head up display (HUD), or a head mounted display system, such as a "near to eye display" system. The display system 214 may comprise display devices that provide three dimensional or two dimensional images, and may provide synthetic vision imaging. Non-limiting examples of such display devices include cathode ray tube (CRT) displays, and flat panel displays such as LCD (liquid crystal displays) and TFT (thin film transistor) displays. Accordingly, each display device responds to a communication protocol that is either two-dimensional or three, and may support the overlay of text, alphanumeric information, or visual symbology.

[0028] As mentioned, the control module 204 performs the functions of the vehicle system 202. With continued reference to FIG. 2, within the control module 204, the processor 250 and the memory 252 (having therein the program 262) form a novel processing engine that performs the described processing activities in accordance with the program 262, as is described in more detail below. The control module 204 generates display signals that command and control the display system 214.

[0029] The control module 204 includes an interface 254, communicatively coupled to the processor 250 and memory 252 (via a bus 255), database 256, and an optional storage disk 258. In various embodiments, the control module 204 performs actions and other functions in accordance with other embodiments. The processor 250 may comprise any type of processor or multiple processors, single integrated circuits such as a microprocessor, or any suitable number of integrated circuit devices and/or circuit boards working in cooperation to carry out the described operations, tasks, and functions by manipulating electrical signals representing data bits at memory locations in the system memory, as well as other processing of signals.

[0030] The memory 252, the database 256, or a disk 258 maintain data bits and may be utilized by the processor 250 as both storage and a scratch pad. The memory locations where data bits are maintained are physical locations that have particular electrical, magnetic, optical, or organic properties corresponding to the data bits. The memory 252 can be any type of suitable computer readable storage medium. For example, the memory 252 may include various types of dynamic random access memory (DRAM) such as SDRAM, the various types of static RAM (SRAM), and the various types of non-volatile memory (PROM, EPROM, and flash). In certain examples, the memory 252 is located on and/or co-located on the same computer chip as the processor 250. In the depicted embodiment, the memory 252 stores the above-referenced instructions and applications 260 along with one or more configurable variables in stored variables 264. The database 256 and the disk 258 are computer readable storage media in the form of any suitable type of storage apparatus, including direct access storage devices such as hard disk drives, flash systems, floppy disk drives and optical disk drives. The database may include an airport database (comprising airport features) and a terrain database (comprising terrain features). In combination, the features from the airport database and the terrain database are referred to map features. Information in the database 256 may be organized and/or imported from an external source 220 during an initialization step of a process.

[0031] The bus 255 serves to transmit programs, data, status and other information or signals between the various components of the control module 204. The bus 255 can be any suitable physical or logical means of connecting computer systems and components. This includes, but is not limited to, direct hard-wired connections, fiber optics, infrared and wireless bus technologies.

[0032] The interface 254 enables communications within the control module 204, can include one or more network interfaces to communicate with other systems or components, and can be implemented using any suitable method and apparatus. For example, the interface 254 enables communication from a system driver and/or another computer system. In one embodiment, the interface 254 obtains data from external data source(s) 220 directly. The interface 254 may also include one or more network interfaces to communicate with technicians, and/or one or more storage interfaces to connect to storage apparatuses, such as the database 256.

[0033] It will be appreciated that the vehicle system 202 may differ from the embodiment depicted in FIG. 2. As mentioned, the vehicle system 202 can be integrated with an existing flight management system (FMS) or aircraft flight deck display.

[0034] During operation, the processor 250 loads and executes one or more programs, algorithms and rules embodied as instructions and applications 260 contained within the memory 252 and, as such, controls the general operation of the control module 204 as well as the vehicle system 202. In executing the process described herein, the processor 250 specifically loads and executes the novel program 262. Additionally, the processor 250 is configured to process received inputs (any combination of input from the communication system 206, the imaging system 208, the navigation system 210, and user input provided via user input device 212), reference the database 256 in accordance with the program 262, and generate display commands that command and control the display system 214 based thereon.

[0035] Turning now to FIG. 3, a block diagram 300 is shown of visual approach path storage and processing in accordance with the disclosed embodiments. Once the aircraft pilot receives the instruction to execute a visual circling approach, the pilot will input 302 various information into the system such as: aircraft type; flight status; any predefined tolerances of the aircraft; runway selection; and any other predefined factors or criteria such as weather conditions, etc. When this function is enabled, the visual approach (VA) engine 304 will process the data and retrieve 306 a list of stored previously flown and factored VA paths. The VA paths are presented to the pilot who may then select a recommended VA path or another VA path from the list shown on the display.

[0036] There are many factors that play a role in executing a visual approach such as pilot experience, awareness of the airport, terrain and obstructions, weather conditions, attentiveness of the pilot etc. As such, the recommended paths retrieved from the database are the optimized paths which intend to reduce the number of missed approaches and go arounds. However, the pilot may choose a VA path other than that recommended by the system,

[0037] In other embodiments, the VA engine will store the visual circling approach paths each time the pilot executes it in each flight to a landing runway of an airport. During operations, the pilot enables the VA Approach Engine with an approach path monitor (APM). Once the visual circling approach is initiated by the pilot, the VA approach engine will start capturing the path until landing and then stores the path for that aircraft, runway and flight along with identified critical parameters and other information. VA approach engine will factor the stored path based on the number of successful landings and add the offsets based on the tolerances defined for the aircraft. The paths are factored in the database based on the number of times the path is flown by the pilot with successful landing. The paths are also factored based on the associated critical parameters that are recorded and stored. The VA engine also will consider any offset differences between the distances of paths. If two paths flown within the offset tolerances as defined, the paths may be merged as a single entry in the database.

[0038] Turning now to FIG.4, an image is shown of a display system screen 400 with a selected visual approach (VA) path in accordance with the disclosed embodiments. The disclosed display system 400 will reduce the pilot workload by reducing the time spent on planning the circling approach in the approach phase by providing a recommended visual circling path. During operations, the pilot selects the Visual approach box 402 where the stored VA paths are listed in the drop-down box. Once maximized, the box shows the list of stored paths listed in order of recommendation with top factored path shown highest. Turning now to FIG. 5, a display 500 is shown of a visual circling approach path 502 in accordance with the disclosed embodiments. Once selected, the designated visual circling approach path 502 map is shown to the pilot on the system display 500.

[0039] FIG. 6 is a flow chart 600 of a method for determining visual approach guidance for an aircraft in accordance with the disclosed embodiments. As an aircraft approaches an airport for landing 602, a visual approach (VA) engine is enabled 604 with an approach path monitor (APM) located onboard the aircraft. An approach path database 608 is accessed 606 that contains multiple visual circling approach paths along with accompanying data for each of the visual circling approach paths. A specific visual circling approach path is selected 610 from the approach path database based on the accompanying data for each of the visual circling approach paths and the aircraft enters 612 the selected specific visual circling approach path.

[0040] Those of skill in the art will appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. Some of the embodiments and implementations are described above in terms of functional and/or logical block components (or modules) and various processing steps. However, it should be appreciated that such block components (or modules) may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention. For example, an embodiment of a system or a component may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. In addition, those skilled in the art will appreciate that embodiments described herein are merely exemplary implementations.

[0041] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0042] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC.

[0043] Techniques and technologies may be described herein in terms of functional and/or logical block components, and with reference to symbolic representations of operations, processing tasks, and functions that may be performed by various computing components or devices. Such operations, tasks, and functions are sometimes referred to as being computer-executed, computerized, software-implemented, or computer-implemented. In practice, one or more processor devices can carry out the described operations, tasks, and functions by manipulating electrical signals representing data bits at memory locations in the system memory, as well as other processing of signals. The memory locations where data bits are maintained are physical locations that have particular electrical, magnetic, optical, or organic properties corresponding to the data bits. It should be appreciated that the various block components shown in the figures may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. For example, an embodiment of a system or a component may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices.

[0044] When implemented in software or firmware, various elements of the systems described herein are essentially the code segments or instructions that perform the various tasks. The program or code segments can be stored in a processor-readable medium or transmitted by a computer data signal embodied in a carrier wave over a transmission medium or communication path. The "computer-readable medium", "processor-readable medium", or "machine-readable medium" may include any medium that can store or transfer information. Examples of the processor-readable medium include an electronic circuit, a semiconductor memory device, a ROM, a flash memory, an erasable ROM (EROM), a floppy diskette, a CD-ROM, an optical disk, a hard disk, a fiber optic medium, a radio frequency (RF) link, or the like. The computer data signal may include any signal that can propagate over a transmission medium such as electronic network channels, optical fibers, air, electromagnetic paths, or RF links. The code segments may be downloaded via computer networks such as the Internet, an intranet, a LAN, or the like.

[0045] Some of the functional units described in this specification have been referred to as "modules" in order to more particularly emphasize their implementation independence. For example, functionality referred to herein as a module may be implemented wholly, or partially, as a hardware circuit comprising custom VLSI circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices, or the like. Modules may also be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, comprise one or more physical or logical modules of computer instructions that may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may comprise disparate instructions stored in different locations that, when joined logically together, comprise the module and achieve the stated purpose for the module. Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network.

[0046] In this document, relational terms such as first and second, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. Numerical ordinals such as "first," "second," "third," etc. simply denote different singles of a plurality and do not imply any order or sequence unless specifically defined by the claim language. The sequence of the text in any of the claims does not imply that process steps must be performed in a temporal or logical order according to such sequence unless it is specifically defined by the language of the claim. The process steps may be interchanged in any order without departing from the scope of the invention as long as such an interchange does not contradict the claim language and is not logically nonsensical.

[0047] Furthermore, depending on the context, words such as "connect" or "coupled to" used in describing a relationship between different elements do not imply that a direct physical connection must be made between these elements. For example, two elements may be connected to each other physically, electronically, logically, or in any other manner, through one or more additional elements.

[0048] As used herein, the term "axial" refers to a direction that is generally parallel to or coincident with an axis of rotation, axis of symmetry, or centerline of a component or components. For example, in a cylinder or disc with a centerline and generally circular ends or opposing faces, the "axial" direction may refer to the direction that generally extends in parallel to the centerline between the opposite ends or faces. In certain instances, the term "axial" may be utilized with respect to components that are not cylindrical (or otherwise radially symmetric). For example, the "axial" direction for a rectangular housing containing a rotating shaft may be viewed as a direction that is generally parallel to or coincident with the rotational axis of the shaft. Furthermore, the term "radially" as used herein may refer to a direction or a relationship of components with respect to a line extending outward from a shared centerline, axis, or similar reference, for example in a plane of a cylinder or disc that is perpendicular to the centerline or axis. In certain instances, components may be viewed as "radially" aligned even though one or both of the components may not be cylindrical (or otherwise radially symmetric). Furthermore, the terms "axial" and "radial" (and any derivatives) may encompass directional relationships that are other than precisely aligned with (e.g., oblique to) the true axial and radial dimensions, provided the relationship is predominantly in the respective nominal axial or radial direction. As used herein, the term "substantially" denotes within 5% to account for manufacturing tolerances. Also, as used herein, the term "about" denotes within 5% to account for manufacturing tolerances.

[0049] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

Claims

1. A system for determining visual approach guidance for an aircraft, comprising:

an aircraft control system comprising a visual approach (VA) engine that is enabled with an approach path monitor (APM) as the aircraft approaches an airport for landing;
an approach path database that contains multiple visual circling approach paths and accompanying data for each of the visual circling approach paths, where the VA engine selects a specific visual circling approach path from the approach path database based on the accompanying data for each of the visual circling approach paths; and
a display unit that displays the selected visual circling approach path to a pilot of the aircraft.

2. The system of Claim 1, where the multiple visual circling approach paths are ranked within the approach path database according to the accompanying data of each visual circling approach path.

3. The system of Claim 2, where the accompanying data of each visual circling approach path comprises the number of times a visual circular approach has been used with a successful landing.

4. The system of Claim 2, where the accompanying data of each visual circling approach path comprises predefined tolerances of the aircraft.

5. The system of Claim 2, where the ranked visual circling approach paths are displayed in order of ranking to a pilot of the aircraft.

6. The system of Claim 2, where a recommended visual circling approach path is displayed to the pilot, where the recommended visual circling approach path is automatically selected based on ranking within the approach path database.

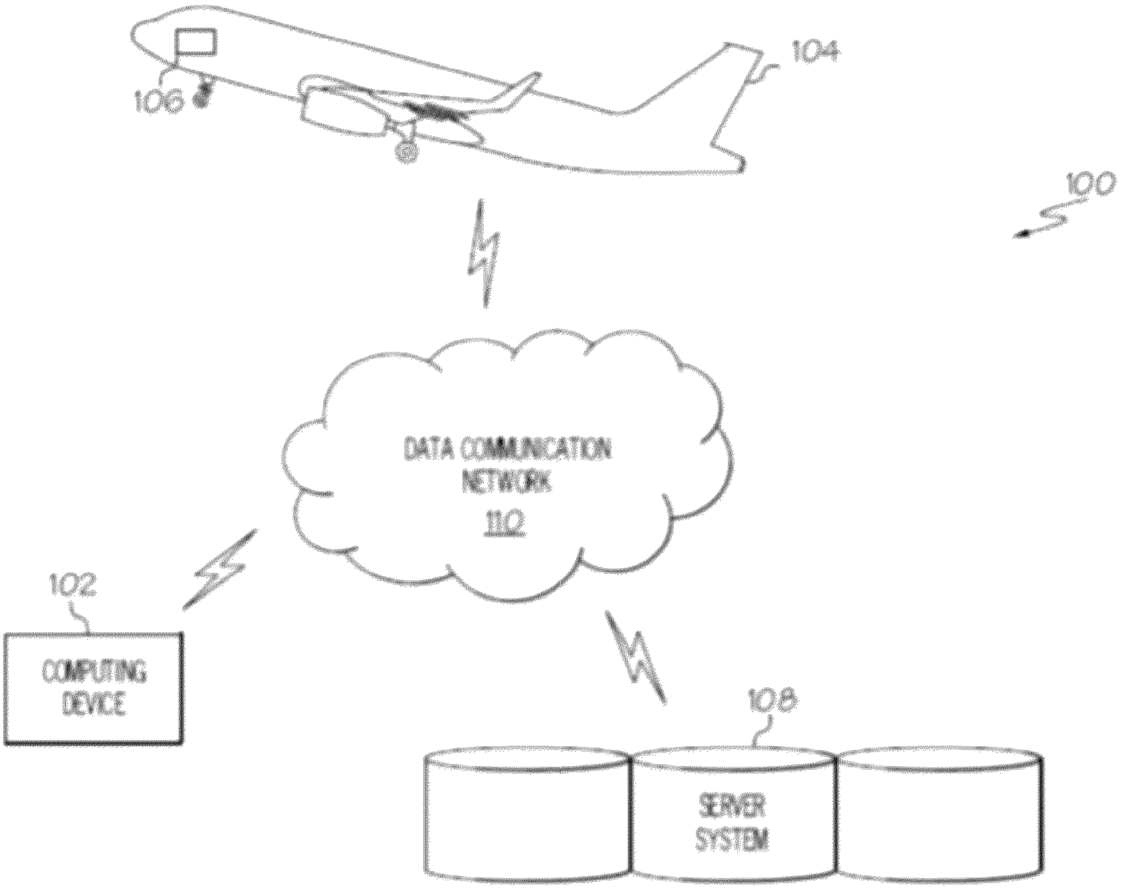
104
106
100
DATA COMMUNICATION
NETWORK
110
102
COMPUTING
DEVICE
108
SERVER
SYSTEM

FIG. 1

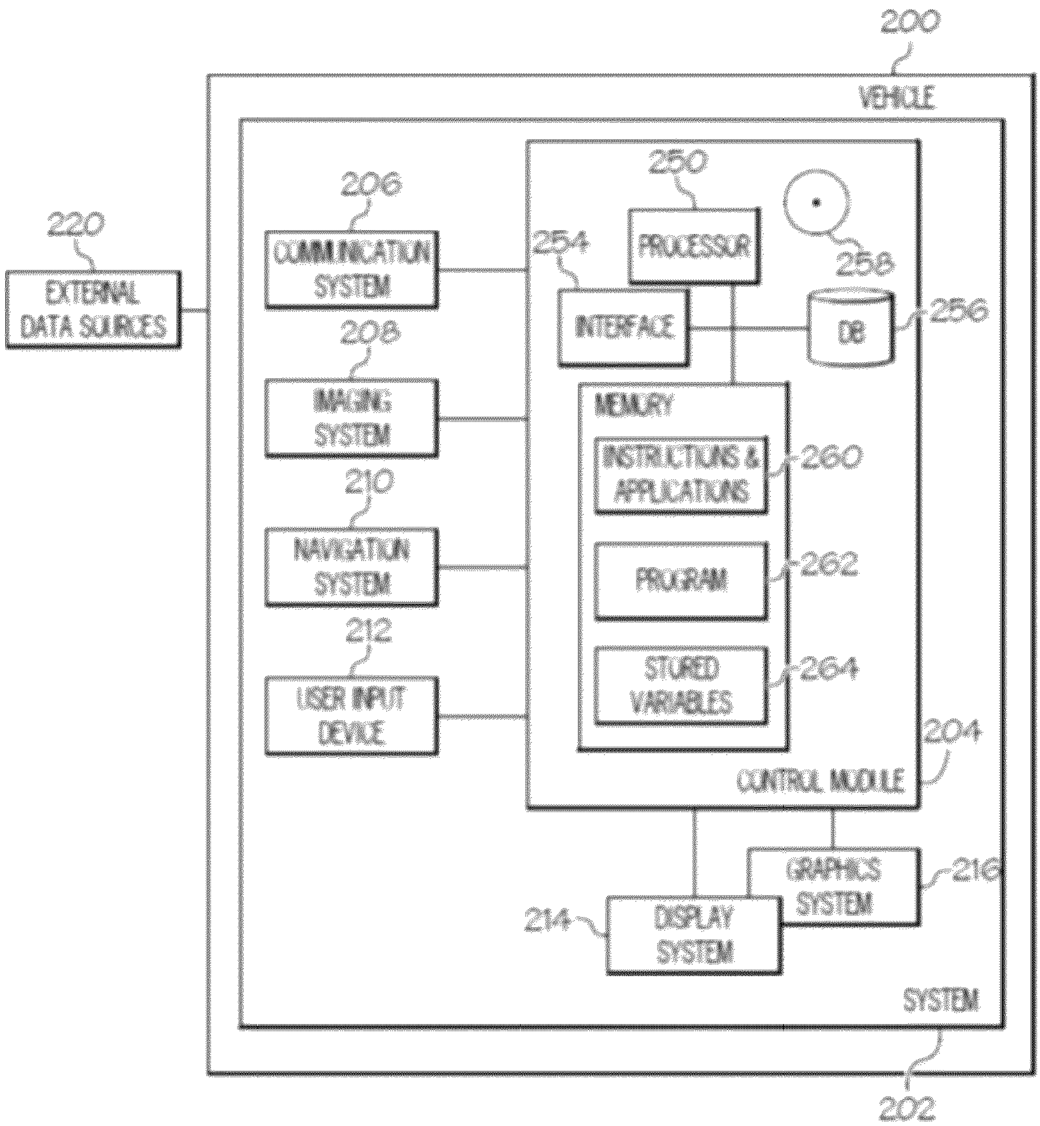
200
VEHICLE
220
EXTERNAL DATA SOURCES
206
COMMUNICATION SYSTEM
208
IMAGING SYSTEM
210
NAVIGATION SYSTEM
212
USER INPUT DEVICE
250
PROCESSOR
254
INTERFACE
258
DB
256
MEMORY
INSTRUCTIONS & APPLICATIONS
260
PROGRAM
262
STORED VARIABLES
264
204
CONTROL MODULE
GRAPHICS SYSTEM
216
214
DISPLAY SYSTEM
SYSTEM
202

FIG. 2

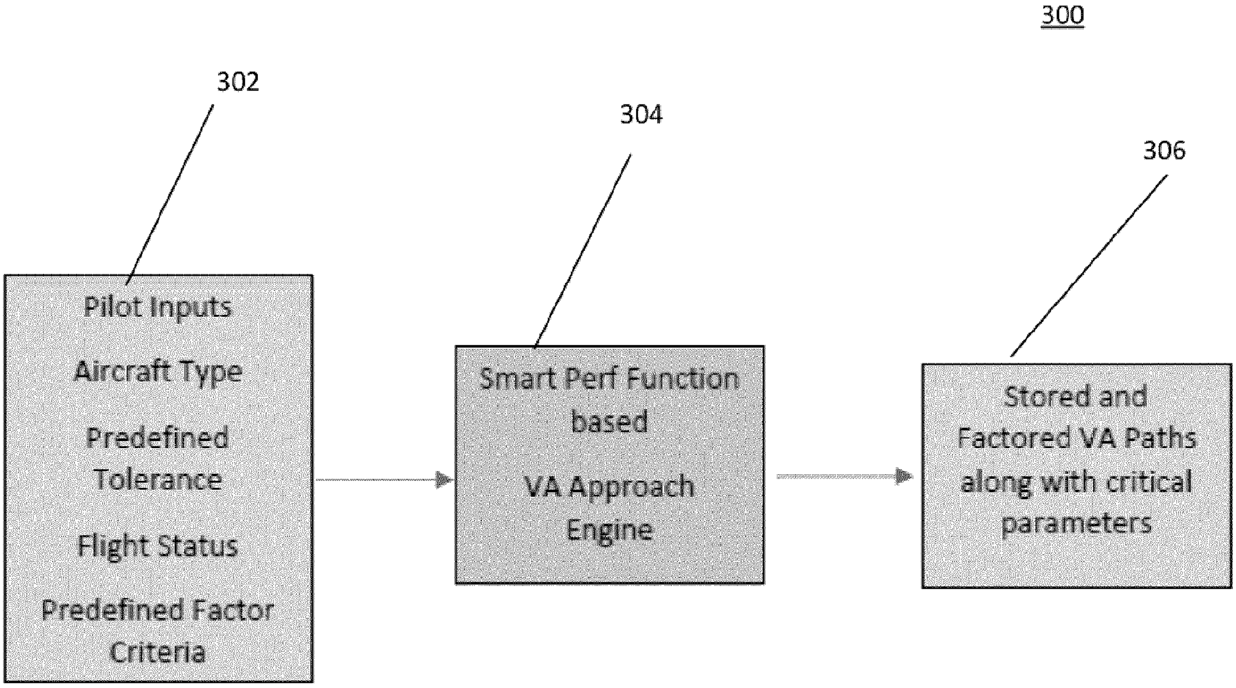
300
302
304
306
Pilot Inputs
Aircraft Type
Predefined Tolerance
Flight Status
Predefined Factor Criteria
Smart Perf Function based
VA Approach Engine
Stored and Factored VA Paths along with critical parameters

FIG. 3

400

402

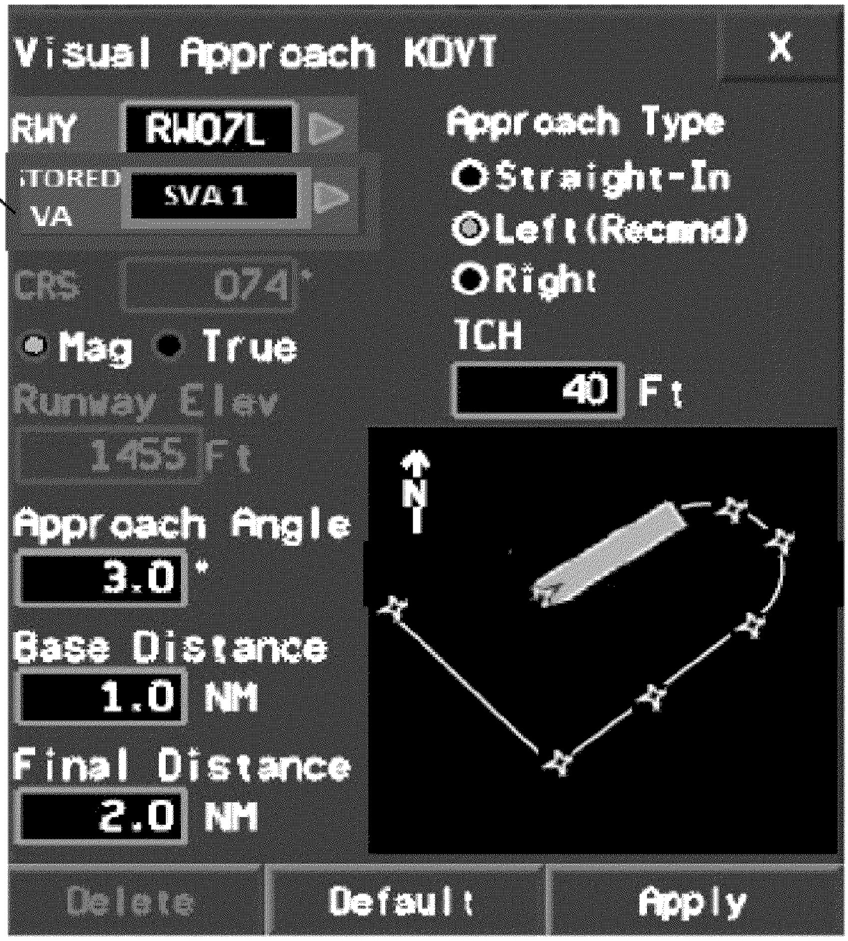
Visual Approach KDVT
X
RWY
RW07L
STORED VA
SVA 1
CRS
074
Mag
True
Runway Elev
1455 Ft
Approach Angle
3.0
Base Distance
1.0 NM
Final Distance
2.0 NM
Approach Type
Straight-In
Left (Recmnd)
Right
TCH
40 Ft
N
Delete
Default
Apply

FIG. 4

500

502

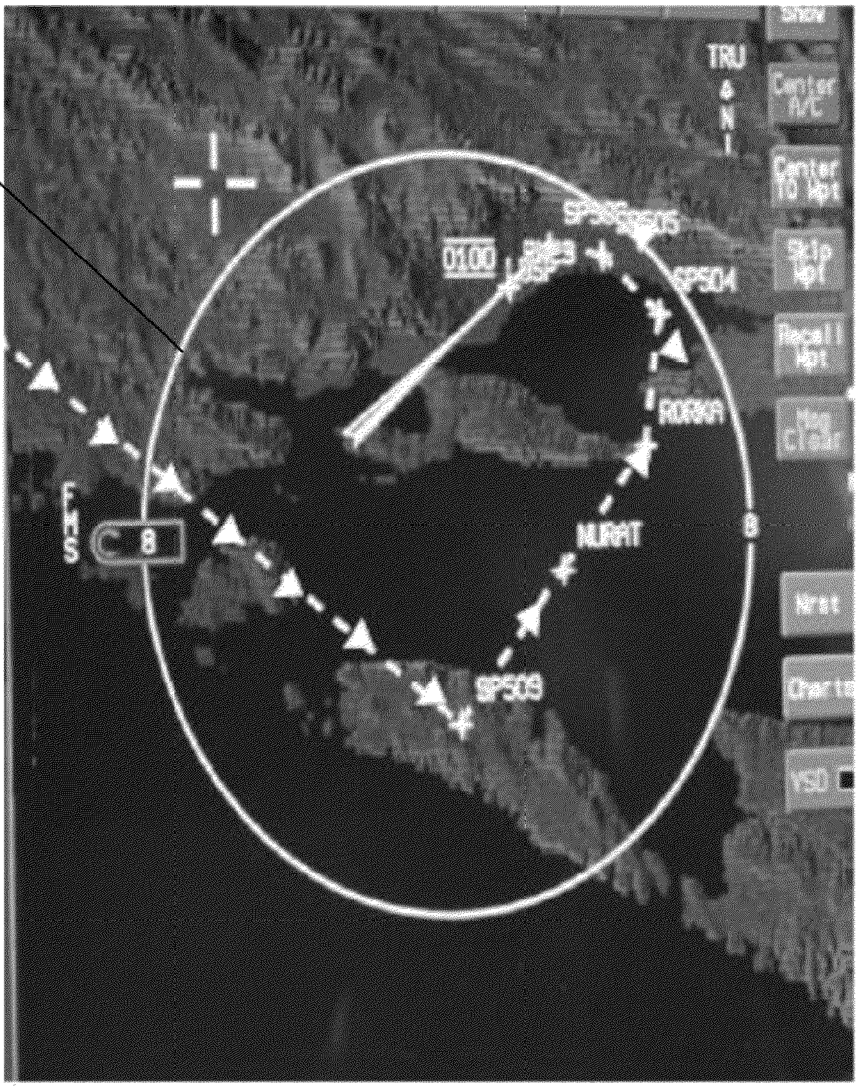
TRU
Center A/C
Center TO Wpt
Skip Wpt
Recall Wpt
Map Clear
Wrst
VSD
FMS
8
0100
SP504
RORKA
NURAT
SP509

FIG. 5

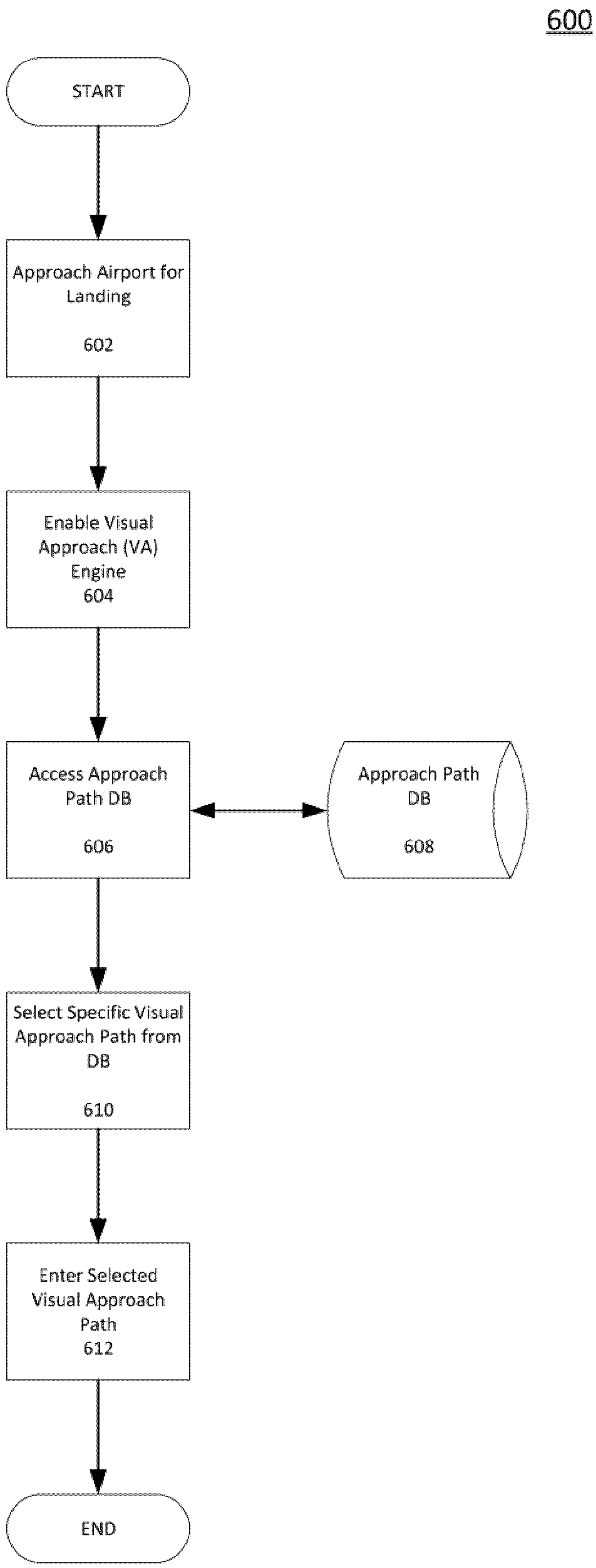
600
START
Approach Airport for Landing
602
Enable Visual Approach (VA) Engine
604
Access Approach Path DB
606
Approach Path DB
608
Select Specific Visual Approach Path from DB
610
Enter Selected Visual Approach Path
612
END

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 24 21 2106

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2021/012671 A1 (ROGER MICHEL [FR] ET AL) 14 January 2021 (2021-01-14) * paragraphs [0002], [0011] - [0013], [0067] - [0070], [0074], [0086] - [0087], [0093], [0101] - [0102], [0124] - [0125] * * paragraphs [0146] - [0148] * * figures 2-8 *	1-6	INV. G08G5/54
A	CN 103 699 132 A (CHINESE AERONAUTICAL RADIO ELECTRONICS RES INST) 2 April 2014 (2014-04-02) * the whole document *	1-6	
A	"System and method to assist the pilot in planning visual approach in the non-towered airfield ED - Darl Kuhn", IP.COM, IP.COM INC., WEST HENRIETTA, NY, US, 7 April 2023 (2023-04-07), XP013195827, ISSN: 1533-0001 * the whole document *	1-6	
A	US 2015/081197 A1 (GAERTNER MARCO [DE] ET AL) 19 March 2015 (2015-03-19) * paragraphs [0001], [0004], [0040], [0052] * * figures 1-8 *	1-6	

TECHNICAL FIELDS SEARCHED (IPC)
G08G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 April 2025	Eitner, Christian

CATEGORY OF CITED DOCUMENTS

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3

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08-04-2025

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		WO 2015038208 A1	19-03-2015

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