SYSTEM AND METHOD FOR SIMULATING A NETWORK OF VEHICLES

TECHNICAL FIELD

[0001] The present invention relates to a system and method for simulating control of one or more vehicles.

BACKGROUND

[0002] The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It may be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

[0003] In recent years there has been increased interest in space exploration facilitated in part due to miniaturized satellites such as a custom-designed satellite (hereinafter referred to as 'CubeSat') and due to the advent of both hardware and software technology. Typically, the CubeSat is launched into space through a space exploratory agency and once launched such CubeSat can then begin to collect data such as space images or perform other space missions. The CubeSat may also be used in network systems developed for space exploration. Such network system can include a space station arranged to data communicate with one or more miniaturized satellites. Software installed on the space station and/or CubeSat facilitate communication and remote control of the CubeSat.

[0004] Simulation systems have been developed to teach and train interested users to build and control miniaturized satellites. Such simulation systems may be broadly classified into professional or leisure use.

[0005] Existing simulation systems designed for professional use are often complex to use without specialized training. Such specialized training may take months, and require years of experience to master. Such simulation systems also offer limited networking capabilities by nature of its niche/customized applications. The systems further require customization to achieve satellite-to-ground station

simulation, customization to tie-in physical hardware into the simulation. The simulation systems are typically very expensive and inaccessible to the general consumers, hobbyists and educators.

[0006] On the other hand, simulation systems designed for general consumer or hobbyist use are often relatively simple and non-rigorous, with emphasis on entertainment rather than simulating accuracy/capabilities. Such simulation systems usually focus on specific/popular aspects of spacecraft simulation (such as rocket launches or flying a spaceship), often neglecting other aspects such as landing, data collection etc. Existing simulators for 'mass-market' users do not simulate ground station operations, satellite-to-ground station simulations, and have no provision for interfacing with real hardware for hybrid simulation, incorporation of current space environment/debris data. Further, simulations of mission planning, environmental simulation capabilities, and multiplayer/networked operations are relatively limited compared to the simulators used for professional users.

[0007] Existing simulators such as CubeSat simulators are typically software based and focused on individual subsystems or a set thereof. Preliminary efforts to simulate hardware behaviour in response to the code "Hardware in the Loop (HIL)" simulators have been derived by NASA and some universities, but these do not integrate actual hardware and real-time orbital simulation data.

[0008] Considering the above, there exists a need to provide an improved simulator which is cost-effective and which provide more features over the 'mass-market' simulators. There exists a further need to alleviate at least one of the drawbacks associated with the simulators for professional users.

SUMMARY OF THE INVENTION

[0009] Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0010] Furthermore, throughout the specification, unless the context requires otherwise, the word "include" or variations such as "includes" or "including", will be

understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0011] Throughout the description, the term client device, computer, or machine can be a physical or virtual terminal device typically used by a user to send and/or receive electronic data to/from a server.

[0012] Throughout the description, the term server can be a physical or virtual computer operating to send and/or receive electronic data to/from a client device.

[0013] The invention was conceptualized to provide a technical solution to facilitate a rigorous simulation environment. A combination of hardware and software features are used to achieve simulations using consumer technology by integrating simulation equations and parameters into the software. The consumer technology is referred to as pre-existing off-the-shelf components that are assembled into a part or whole of space systems. These components may include, but not be limited to, a server, satellite hardware, ground station hardware and computer hardware used to host the simulation environment. These components are typically neither designed nor certified for use in the space systems.

[0014] The disclosed system provides users with a generic interface to interface various spacecraft hardware such as CubeSat with the simulation tool, bi-directional data communication between the hardware and simulation tool, and the hardware state into the simulator and operations within which the simulator can affect the hardware state.

[0015] In some embodiments, there is a system for simulating a network of vehicles including: a central server having a simulator operable to receive at least one simulation parameter from a vehicle; and a terminal device arranged in data communication with the central server, the terminal device operable to send and receive the simulation parameter to/from the simulator; wherein the simulation parameter includes hardware parameter and/or software parameter, hardware parameter and/or software parameter in a real-world are capable of being related to hardware parameter and/or software parameter in a virtual-world and vice versa.

[0016] In some embodiments, the hardware parameter and/or the software parameter in the real-world are translated into the hardware parameter and/or the software parameter in the virtual-world and vice versa, by mapping between the hardware parameter and/or the software parameter in the real-world and the hardware parameter and/or the software parameter in the virtual-world.

[0017] In some embodiments, the simulator is operable to set a simulation environment.

[0018] In some embodiments, the vehicle is operable to generate the hardware parameter and/or the software parameter in the virtual-world, as a response to the simulation environment.

[0019] In some embodiments, the response regarding the generated hardware parameter and/or software parameter is integrated.

[0020] In some embodiments, a corresponding simulation of a location of the vehicle in the real-world is integrated into the simulation environment in the virtual-world.

[0021] In some embodiments, an environmental factor in the real-world is integrated into the simulation environment in the virtual-world.

[0022] In some embodiments, the response is characterized by monitoring the generated hardware parameter and/or software parameter in the virtual-world under the simulation environment.

[0023] In some embodiments, if it is determined that the characterized response is satisfactory, the simulator is operable to enter the characterized response into the hardware parameter and/or the software parameter in the real-world; and if it is determined that the characterized response is not satisfactory, the characterized response is rectified and/or re-characterized.

[0024] In some embodiments, the characterized response with an actual environmental value associated with the simulation environment is used on an actual operation of the vehicle to scope or mitigate a behaviour of the vehicle in the real-

world.

[0025] In some embodiments, the hardware parameter and/or the software parameter in the real-world are capable of being related to the hardware parameter and/or the software parameter in the virtual-world and vice versa by at least one of the terminal device, the simulator or a dedicated device.

[0026] In some embodiments, the central server comprises at least one database operable to store data relating to at least one type of the vehicles.

[0027] In some embodiments, the vehicles include at least one of space vehicle or aerial vehicle.

[0028] In some embodiments, the hardware parameter includes at least one of the following: material and dimensions of the vehicle, electronics layout and connections, or amount of fuel.

[0029] In some embodiments, the software parameter includes at least one of the following: software running on a hardware and/or a processor in the vehicle, or software processing communication between the vehicle and another vehicle and/or a ground station.

[0030] In some embodiments, there is a method for simulating a network of vehicles including: receiving, at a simulator of a central server, at least one simulation parameter from a vehicle; and sending and receiving, at a terminal device in data communication with the central server, the simulation parameter to/from the simulator, the simulation parameter includes hardware parameter and/or software parameter; wherein hardware parameter and/or software parameter in a real-world are capable of being related to hardware parameter and/or software parameter in a virtual-world and vice versa.

[0031] In some embodiments, the method further comprises steps of translating the hardware parameter and/or the software parameter in the real-world into the hardware parameter and/or the software parameter in the virtual-world, and vice versa; setting a simulation environment by the simulator; and generating hardware parameter and/or software parameter in the virtual-world, as a response to the

simulation environment.

[0032] In some embodiments, the method further comprises steps of integrating the response regarding the generated hardware parameter and/or software parameter; and characterizing the response by monitoring the generated hardware parameter and/or software parameter in the virtual-world under the simulation environment.

[0033] In some embodiments, the method further comprises steps of determining if the characterized response is satisfactory; if it is determined that the characterized response is satisfactory, entering the characterized response into the hardware parameter and/or the software parameter in the real-world; and if it is determined that the characterized response is not satisfactory, rectifying and/or re-characterizing the characterized response.

[0034] Other aspects and features of the present invention will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0036] Fig. 1 is an overall architecture of an embodiment of the present invention showing how the various parts of the system interact.

[0037] Fig. 2 is a flowchart of an embodiment of the present invention showing how the system simulates control of a vehicle.

[0038] Fig. 3 is a flowchart of an embodiment of the present invention showing how the hardware parameters and software parameters in the real-world are related to the virtual-world and vice versa.

[0039] Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

DESCRIPTION OF EMBODIMENTS

[0040] Throughout the description, the term ‘user’ and its plural form may include, and is not limited to a general consumer, service provider, operator, network administrator etc.

[0041] Throughout the description, the term ‘vehicle’ and its plural form may include space or aerial vehicle. The space or aerial vehicles may comprise, but not be limited to, a plurality of satellites, in particular miniaturized satellites such as CubeSat, spacecraft, ballistic missiles and high-altitude balloons. The miniaturized satellites may also include other nano-satellites not explicitly mentioned. It is to be appreciated that the satellites may orbit an object such as the Earth, planets, asteroids, extra-solar objects.

[0042] Throughout the description, the term ‘simulator’ and its plural form are understood to include a system of simulation, and may also include hardware and software components arranged to achieve the various functions of simulation. The simulator may also include features and aspects of modelling. The simulator may be arranged in the central server, for example in the form of unit or module.

[0043] Fig. 1 is an overall architecture of an embodiment of the present invention showing how the various parts of the system 100 interact. Fig. 2 is a flowchart of an embodiment of the present invention showing how the system simulates control of a vehicle. The system 100 may comprise a central server 110, a terminal device 120 and one or more vehicles 130 (131, 132). The central server 110 may comprise a simulator 111 and a database 112. The database 112 is operable to store data relating to at least one type of the vehicles 130.

[0044] According to an aspect of the invention or disclosure there is a system 100 for simulating control of one or more vehicles 130. The vehicles 130 may include, but not be limited to, space vehicles and aerial vehicles. The system 100 is

particularly suited to simulate a network comprising the vehicles 130.

[0045] The system 100 includes a hardware processor which may be an integrated circuit (IC) chip having data processing capabilities. It is appreciable that the processor may also include a personal computer and/or laptop computer having the necessary user interface which includes keyboards, monitors, communication ports etc. The processor may also include remote components arranged in data communication with the laptop computer. Such remote components may include cloud servers, databases etc. The processor will include non-transitory machine/computer readable medium. It is therefore appreciable that the various components described may be regarded as a 'central server 110'. The central server 110 may be referred to as a 'platform'.

[0046] The central server 110 operates to receive data from a plurality of vehicles 130, for example satellites (S210 of Fig. 2). These satellites may be user-built, integrated CubeSats. The central server 110 contains software instructions installed thereon such that when executed on the non-transitory computer readable medium, provide users with pre-determined or periodic updates on the data of a selected group of, or every satellite in the network.

[0047] The data may include, but not be limited to, the physical or simulated location of the satellite, low earth orbit coordinates, local space weather conditions, and the physical or simulated location of other satellites on the network. Relative location data of one or more satellites with respect to one or more other satellites in the network may also be provided.

[0048] In some embodiments, the central server 110 may offer a realistic mission experience through virtual orbital decay, interaction with nearby spacecraft (if any), and space environment variability mitigation. Users will have the opportunity to enhance their hardware and software (see below) through the purchase of virtual orbit boosts, advanced payloads, and spacecraft-related apps. It may be appreciated that the central server 110 may be used as an entertainment platform for consumers to learn and simulate the space systems. It may also be appreciated that the central server 110 may be used to lower the barrier of entry for professionals and/or corporations with limited experience to enter or make use of the space industry.

[0049] In some embodiments the central server 110 may progressively serve higher resolution data, via location based system such as Google Earth and other datasets to users who purchase upgrades, since a plurality of new vehicles 130 such as satellites and spacecraft will take high resolution data which will be made available to users.

[0050] In some embodiments, the system 100 can maintain an accurate representation of the real-world space environment so that users can use the simulator 111 for real-world mission planning and spacecraft simulation. The accurate representation can be achieved through integration of real-time data drawn from the satellites, space weather and/or other related datasets.

[0051] To achieve the accurate representation, the real-time data can be integrated. For example, the real-time data of real-world satellites and their orbits can be drawn, and a corresponding simulation of the location of the real-world satellite can be integrated into a simulation environment to allow the users to plan missions involving the real-world satellites. In another example, real-world space weather data can be integrated into the simulation environment so that the users can react to real-world scenarios. In this manner, if there is an oncoming solar burst in the real-world, the users can practice how to avoid damage from the solar burst. The unpredictability of the real-world also helps to teach the users how to prepare and handle unexpected scenarios.

[0052] It is to be appreciated that the simulator 111 of the central server 110 provides for a simulation environment using a central server 110 defined and/or consumer defined simulation equations and parameters. For example, some simulation environments such as gravity and orbit calculations are defined by the central server 110 so that the users can exist in the same environment. It is to be appreciated that the users can override some simulation environments defined by the central server 110 for their own isolated simulation. The parameters may include variables and constants. The simulation equations and parameters may vary over time depending on context, domain knowledge and other environmental factors. Such information relating to the changes in the simulation equations and parameters may be gathered or collated over a period of time and stored in the database 112.

Rule-based knowledge database may be built up over time and form part of a rule-based expert system or machine learning system.

[0053] In some embodiments, simulations may be expressed as mathematical equations involving multiple input variables and output variables. For simulations, the equations are complex differential equations played out (also referred to as 'extrapolated' or 'propagated') over time intervals. For example, the simulator 111 utilises the equations for modelling or predicting the orbit of an object through the Earth's higher orbit which takes into account the variations in gravitational pull across the Earth, the almost negligible amount of air resistance, photon pressure from the sun, and so on. Another example is modelling the change in temperature across an object as it rotates in its own orbit, orbits another object/planet, and goes in and out of the sun's coverage. This can also cause minute changes in the satellite's shape and affect the amount of thrust required (especially for thrusters that impart little momentum, like ion thrusters) to change course of travel, etc. For example, a mission travelling towards Pluto may require correction of course of travel as unpredictable forces from the sun or other space bodies may change the direction and/or course of travel for the spacecraft. Thus, thrusters may be required to nudge the spacecraft back towards its intended course.

[0054] In some embodiments, one or more user interfaces may be provided to users of the system 100. The one or more user interfaces provide for hardware interfacing with the simulation software. In some embodiments, the users may be provided with a generic interface they can use to interface with various spacecraft hardware modeled as one or more space or aerial vehicles 130. The generic interface may operate in a bi-directional manner. One direction may include feeding information about the hardware state of the spacecraft into the simulator 111 and the other direction may include the simulator 111 sending information to affect/effect a hardware state.

[0055] In some embodiments, different users simulating their respective spacecraft/ground stations can choose to interact with each other in the same environment to collaborate on missions and simulations (either as a game/entertainment, or for planning real-life scenarios, e.g. NASA and ESA

coordinating their ground stations for telemetry during an inter-continental spacecraft launch)

[0056] In some embodiments, the simulator 111 provides a simplified scripting and configuration parameters for the users, such as consumers/students, and increasingly complex levels of control for hobbyists and professionals who need it. In other words, the simulator 111 caters to differing level of experience of each user by providing different levels of control to each user or user groups. This may be achieved in part by providing input fields via the input interfaces to the users for each user to select his/her level of experience (for example, novice, hobbyist, professional). It may be appreciated that the users can directly control the simulation parameters or write scripts/software to automatically change the simulation parameters. The terminal device 120 of the users is arranged in data communication with the central server 110. The terminal device 120 is operable to send and receive the simulation parameters, for example the simplified scripting and configuration parameters, to/from the simulator 111 (S220 of Fig. 2).

[0057] In some embodiments, the parameters such as hardware parameters and/or software parameters of the vehicle 130, for example satellite, in the real-world are capable of being related to parameters in the virtual-world and vice versa (S230 of Fig. 2). The hardware parameters may include, but not be limited to, material and dimensions of the vehicle 130, electronics layout and connections, or amount of fuel, etc. The software parameters may include, but not be limited to, software running on specific hardware and/or processors in the vehicle 130, or software processing the communication between the vehicle 130 and another vehicle and/or a ground station, etc.

[0058] As an example, a physical spacecraft and its software may be translated into the simulation environment to simulate different missions. The final program used to carry out the missions, obtained through the simulation environment, can then be translated back into the physical spacecraft's actual software and used to run the actual spacecraft. In the simulator 111, the hardware responds to a simulation environment, for example sample flight and operations conditions. Here, the hardware may include, but not be limited to, the satellite per se or other hardware

as a part of the satellite system, for example the ground station and control system and their associated intermediate hardware.

[0059] In some embodiments, to allow parameters in the real-world to be related to parameters in the virtual world and vice versa, at least one of translation, integration, characterization or rectification can be performed. It may be appreciated that additional process can be performed to allow the parameters in the real-world to be related to the parameters in the virtual world and vice versa. Although not shown, it is to be appreciated that there may be a dedicated device operable to interface and perform the at least one of translation, integration, characterization or rectification. It is also to be appreciated that a plurality of devices such as the terminal device 120, the central server 110 or the dedicated device may be involved in the at least one of translation, integration, characterization or rectification. For example, while the dedicated device performs the translation, the central server 110 performs integration, characterization and rectification. It may be appreciated that for consumers using the system 100 as an education tool, the terminal device 120 may perform the translation, integration, characterization and rectification. For industrial or professional users, the central server 110 may perform the translation, integration, characterization and rectification.

[0060] For example, the simulator 111 of the central server 110 can translate hardware parameters and/or software parameters in the real-world into hardware parameters and/or software parameters in the virtual-world, and vice versa. The translation may include a simple mapping of the hardware parameters and/or software parameters between the real-world and the virtual-world. The translation may be performed periodically based on development needs or continuously. In some embodiments, the translation may be required for the integration to occur.

[0061] The simulator 111 can set a simulation environment. The real-world vehicle 130 is operable to generate hardware parameter and/or software parameter in the virtual-world, as a response to the simulation environment.

[0062] The simulator 111 can then integrate the response regarding the hardware parameters and/or the software parameters generated by the real-world vehicle 130 under the simulation environment in the virtual-world.

[0063] With regards to the integration of the hardware parameters, the hardware parameters may be provided in the form of value of additional sensors and/or actuators integrated into the real-world vehicle 130. For example, the hardware parameters may be continuously translated between the real-world vehicle 130 and virtual-world vehicle. It may be appreciated that extra software code can be added so that the real-world vehicle 130 can accept parameter changes and/or reports from/to the simulation environment as a part of a software program of the system 100.

[0064] With regards to the integration of the software parameters, the software parameters are used to re-compile or cross-compile the software program by the simulator 111. The re-compiled or cross-compiled software program may run on the simulation environment. It may be appreciated that some libraries and/or software hooks can be provided for the software integration to interface with the simulation environment.

[0065] If more accurate or exact simulation is required, the simulator 111 may simulate a virtual copy of an actual processor and its associated electronic device and/or peripheral device in the simulation environment, and the real-world software may be loaded and run on the virtual processor without modification.

[0066] The response then can be characterized by the simulator 111. The characterization is to measure or evaluate how the vehicle 130 responds to the simulation environment, for example various stimuli or environments. The characterized response is used to modify the vehicle's 130 hardware and software so that the desired response to the stimuli or environments can be obtained.

[0067] The form of the characterized response may depend on the user and/or the use case scenarios. For example, to characterize a battery charge level scenario during extended time without sun exposure, the user may measure the battery voltage and software behaviour as a response. The characterized response may be based on a predetermined decision tree drawn by an engineering team on how the software should behave depending on battery voltage. As another example, to characterize a course correction due to solar winds, the user may measure the course and thruster outputs of the vehicle 130 as response. The characterized

response may be based on orbital equations governing the vehicle's 130 movement and impulse equations for the thrusters.

[0068] Once the response is characterized by the simulator 111, the characterized response with actual environmental value associated with the simulation environment is used on the actual flight model to scope and mitigate, if necessary, the hardware behaviour under the anticipated space conditions in the real-world. In some embodiments, the response may be characterized by monitoring how the hardware parameters and/or the software parameters respond to the inputs provided in the scenario or the simulation environment set by the simulator 111. For example, if there is insufficient sunlight during a certain period of a year (i.e. an input) and the battery drains are too low (i.e. one possible scenario as a result of the input), the response or output may be how the satellite handles it.

[0069] Fig. 3 is a flowchart of an embodiment of the present invention showing how the hardware parameters and software parameters in the real-world are related to the hardware parameters and software parameters in the virtual-world and vice versa. The user may have hardware and software for a real-world vehicle 130 that the user wishes to test out without using real-world tests.

[0070] Firstly, a forward translation process can be performed (S310 of Fig. 3). The user may create the mechanical model and re-compile the software of the vehicle 130 for the simulator 111. Thus, there is a virtual copy of the vehicle 130 including its software in the simulator 111. It may be appreciated that the real-world vehicle 130 and virtual-world vehicle are independent of each other after the translation.

[0071] Thereafter, an integration process can be performed (S320 of Fig. 3). The user may set up the simulator 111 and the real-world vehicle 130 that any stimulus applied to the real-world vehicle 130 also affects the virtual-world vehicle and vice versa. Therefore, both the real-world vehicle 130 and the virtual-world vehicle now operate in sync to various extents depending on what the user wishes to achieve.

[0072] A characterization process can then be performed (S330 of Fig. 3). The simulator 111 may set various stimuli and environments, for example a

micrometeorite collision while trying to take a satellite photo and causing the camera to wrongly point partway through a photo exposure. The vehicle's 130 response to the scenarios are recorded. For example, the response may include an action that the vehicle 130 fires its thrusters to recover from the wrong point. It may be appreciated that due to the integration, the user can choose to simulate the micrometeorite collision in the real-world by firing an appropriate projectile at the real-world vehicle 130 which will generate more realistic data than the simulation environment, and then observe the response by the vehicle's 130 thrusters in the simulation environment. This is safer, easier and less costly than a thruster test chamber in the real-world.

[0073] The user, for example engineers, may examine the characterized response and determine if it is appropriate or satisfactory (S340 of Fig. 3). In some embodiments, the simulator 111 and/or the terminal device 120 can examine the characterized response and determine if it is appropriate or satisfactory. If it is determined that the characterized response is not satisfactory, the characterized response is rectified (S350 of Fig. 3) and/or re-characterized (S330 of Fig. 3). A program and/or physical design changes are then made and applied to the virtual-world vehicle, and characterization is carried out again. This may repeat until the response is determined to be satisfactory results.

[0074] After all scenarios are tested with satisfactory results, the software in the virtual-world vehicle can be re-compiled for the real-world vehicle 130, and physical design changes made on the virtual-world vehicle can be replicated on the real-world vehicle 130 by back translation (S360 of Fig. 3). In this manner, parameters in the real-world is capable of being related to parameters in the virtual-world and vice versa.

[0075] The sample flight and operations conditions are close to or the same as the actual flight of the real-world. Therefore, the flaws or problems with the real-world hardware and software can be identified in advance and rectified without the cost and risk of real-world testing, with reference to the simulation results. Since the flaws or problems can be rectified via the simulation in the virtual-world and the rectified information can be used on the actual flight model, the flaws or problems can be

significantly reduced.

[0076] Advantageously, the conversion between the physical spacecraft and simulation environment allows rapid development to occur by quickly iterating between refining the physical spacecraft and testing it out in the virtual environment.

[0077] End-to-end spacecraft simulation- Not only is the spacecraft simulated, it is possible to simulate the spacecraft's launch, ground station operations and coordination between ground stations and spacecraft

[0078] Education tool- By simplifying the hardware and software, it is possible for educators to use the system 100 as an education tool to teach students various aspects of spacecraft design and operations

[0079] The system 100 will next be described in the context of a user receiving a CubeSat kit to assemble according to detailed instructions. Each user will be challenged to integrate their CubeSats into a server on a laptop or mobile device using pre-designed scripts as a first step in the spacecraft launch readiness system 100. Conventionally normal tools are not able to be controlled by the software. However, in accordance with some embodiments of the invention, the CubeSat kit can be controlled by the software.

[0080] In addition, each user or a group of users may receive a script-based software kit with tutorial. This software code associated with the script-based software kit can be executed from a terminal device 120, for example a mobile phone, tablet device or computer device (laptop or desktop), to bridge the hardware system to a simulated space environment. After initialization of the system, a user may choose to receive one or more "mission" status updates via the terminal device 120. Basic mission status data will be presented in a similar or established format.

[0081] In some embodiments, apps or plugins for the terminal device 120, for example mobile device or computer platforms may be provided. These apps or plugins may offer enhanced data quality and details regarding networked virtual satellites. In addition, users will be able to view live tracks of actual satellites in orbit. Positional data and orbital tracks may be provided, along with an image of celestial bodies in the space, for example the Earth, taken from the International Space

Station (ISS) or other spacecraft orbiting any other celestial body.

[0082] In some embodiments, the software architecture can be scalable. Elements of scalability may include telemetry, tracking and command modules, electric power system (EPS), payload, sensors, on-board computer (OBC), thrusters, parachutes (for lander-type simulations instead of satellites), deployable antennas/legs, driving wheels (for rover-type simulations) etc.

[0083] In some embodiments, the system 100, network of vehicles 130 and/or user's terminal devices 120 may communicate with the central server 110 via a reliable radio-frequency link, integrated into the telemetry, tracking and command modules.

[0084] In some embodiments, the software environment server (service) that simulates some planetary motion with respect to other user satellites that can be launched from various locations and put into orbit:

a. Accurately simulates launch and/or orbital conditions, for example Rocket thrust, orbit insertion path, solar irradiation angle/power, elliptic orbits, atmospheric drag, position of visible stars, magnetic torqueing, etc.

b. Simulation conditions can be turned on or off by the user for each satellite.

c. Satellites can be programmed to interact with the virtual environment, or with each other, for example rotate their solar panels depending on solar angle, perform inter-satellite co-operation missions, etc.

[0085] Software client that connects to the server and allows the user to manipulate and interact with the virtual environment (for example, to launch a satellite, issue commands, perform experiments, etc.), and bridges the virtual environment to the simulation hardware:

a. Clients may be implemented in a browser, for example using Chrome Apps.

b. Clients may be implemented in cross-platform toolkits, for example Java, Python with GTK+, etc.

c. Clients may be implemented in native Windows/Mac/Linux software.

d. Clients communicate to the simulation hardware via wired protocol, for example USB serial, or wireless protocol.

[0086] This invention will evolve to incorporate data from the Moon, Mars, asteroids, and other celestial bodies as the commercial and government space sectors continue to build knowledge through new spacecraft or remote sensing mission in outer space.

[0087] This invention will evolve to incorporate datasets relevant to human exploration, such as energy levels relevant to biological life, as human presence in space becomes a reality through space tourism and these data become available.

[0088] This invention will evolve to simulate in-orbit self-assembly of CubeSats as this technology becomes viable.

[0089] It should be further appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to form yet further embodiments falling within the intended scope of the invention.

CLAIMS

1. A system for simulating a network of vehicles including:

a central server having a simulator operable to receive at least one simulation parameter from a vehicle; and

a terminal device arranged in data communication with the central server, the terminal device operable to send and receive the simulation parameter to/from the simulator;

wherein the simulation parameter includes hardware parameter and/or software parameter, hardware parameter and/or software parameter in a real-world are capable of being related to hardware parameter and/or software parameter in a virtual-world and vice versa.

2. The system according to claim 1, wherein the hardware parameter and/or the software parameter in the real-world are translated into the hardware parameter and/or the software parameter in the virtual-world and vice versa, by mapping between the hardware parameter and/or the software parameter in the real-world and the hardware parameter and/or the software parameter in the virtual-world.

3. The system according to claim 2, wherein the simulator is operable to set a simulation environment.

4. The system according to claim 3, wherein the vehicle is operable to generate hardware parameter and/or software parameter in the virtual-world, as a response to the simulation environment.

5. The system according to claim 4, wherein the response regarding the generated hardware parameter and/or software parameter is integrated.

6. The system according to claim 5, wherein a corresponding simulation of a location of the vehicle in the real-world is integrated into the simulation environment in the virtual-world.

7. The system according to claim 5, wherein an environmental factor in the real-world is integrated into the simulation environment in the virtual-world.

8. The system according to claim 5, the response is characterized by monitoring the generated hardware parameter and/or software parameter in the virtual-world under the simulation environment.

9. The system according to claim 8, wherein if it is determined that the characterized response is satisfactory, the simulator is operable to enter the characterized response into the hardware parameter and/or the software parameter in the real-world; and
if it is determined that the characterized response is not satisfactory, the characterized response is rectified and/or re-characterized.

10. The system according to claim 9, wherein the characterized response with an actual environmental value associated with the simulation environment is used on an actual operation of the vehicle to scope or mitigate a behaviour of the vehicle in the real-world.

11. The system according to claim 1, wherein the hardware parameter and/or the software parameter in the real-world are capable of being related to the hardware parameter and/or the software parameter in the virtual-world and vice versa by at least one of the terminal device, the simulator or a dedicated device.

12. The system according to claim 1, wherein the central server comprises at least one database operable to store data relating to at least one type of the vehicles.

13. The system according to claim 1, wherein the vehicles include at least one of space vehicle or aerial vehicle.

14. The system according to claim 1, wherein the hardware parameter includes at least one of the following: material and dimensions of the vehicle, electronics layout and connections, or amount of fuel.

15. The system according to claim 1, wherein the software parameter includes at least one of the following: software running on a hardware and/or a processor in the vehicle, or software processing communication between the vehicle and another vehicle and/or a ground station.

16. A method for simulating a network of vehicles including:

receiving, at a simulator of a central server, at least one simulation parameter from a vehicle; and

sending and receiving, at a terminal device in data communication with the central server, the simulation parameter to/from the simulator, the simulation parameter includes hardware parameter and/or software parameter;

wherein hardware parameter and/or software parameter in a real-world are capable of being related to hardware parameter and/or software parameter in a virtual-world and vice versa.

17. The method according to claim 16 further comprising steps of:

translating the hardware parameter and/or the software parameter in the real-world into the hardware parameter and/or the software parameter in the virtual-world, and vice versa;

setting a simulation environment by the simulator; and

generating hardware parameter and/or software parameter in the virtual-world, as a response to the simulation environment.

18. The method according to claim 17 further comprising steps of:

integrating the response regarding the generated hardware parameter and/or software parameter; and

characterizing the response by monitoring the generated hardware parameter and/or software parameter in the virtual-world under the simulation environment.

19. The method according to claim 18 further comprising steps of:

determining if the characterized response is satisfactory;

if it is determined that the characterized response is satisfactory, entering the characterized response into the hardware parameter and/or the software parameter in the real-world; and

if it is determined that the characterized response is not satisfactory, rectifying and/or re-characterizing the characterized response.