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Waypoint Navigation on Mars for the Purpose of Exploration

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Abstract—*Mars has always been a sort of a fantasy for mankind. Since the first satellite reached Mars, Mariner 9 to the arrival of Curiosity rover on Mars, we have always wondered about how the surface of Mars will react to our intrusion. Although with Curiosity, we have come to know a lot about the Martian atmosphere and surface, weather and climatic changes, still most area of Mars remains unexplored. With the development of technology, we are now close to be capable of sending a human to Mars for further detailed study. But that will be dangerous if we don't have proper directions for navigating on Mars. In such cases, waypoint navigation can be of great help.*

What it will include is placing 16 satellites in orbit of Mars on the hypothetical geometrical axis of the 4 orbital plane. These 16 satellites will divide the Martian surface into small grids and each grid will have its own identity. It will divide the Mars into the same way as we have on Earth, the latitude and longitude. With the help of this technology, we will be able to have a unique address in terms of latitude and longitude for every place. This will help us in many ways. It can be used to guide a rover into any possible direction autonomously and to longer distances. Also, once the human race reaches Mars, we will be have the means of navigation to the required work place without much difficulty. It will also help us in returning back to the base. So in this way, this technology will be of great help for the rovers and the humankind.

1. INTRODUCTION

Exploration has always been in the blood of humans. The moment we visit some new city or find some new topics on the internet, we get eager to explore more and more about it. This world is the witness of those days when the Northern star was used as a reference for exploring the world during the age of Vikings. But with the passage of time, and the advancement of technology, we no more have to be dependent on stars and moon as the reference point. The world developed and compass came into existence, and then maps. But recent developments have enabled us to go anywhere on Earth, without the fear of getting lost. With the commencement of space age, the United States Military, particularly the USAF proposed, launched with the help of NASA and established what is globally used today for the purpose of navigation and exploration, which is GPS, or Global Positioning System.

The Global Positioning System has been a revolutionary technology in today's world. This system was primarily developed for the US military, but it was then made available for public use in the 1980's. Since then, it has only worked for the betterment of the world as it have revolutionized the exploration and navigation sector. The most important feature of GPS is to tell the pin point location and direction. This enables us to navigate to our destination with easy and without the fear of getting lost. This saves a lot of time, as well as it makes us independent of other factors. Time to time updates help us keep the device modern and technologically advanced.

2. GLOBAL POSITIONING SYSTEM ON EARTH

The development of GPS for the Earth is credited to the United States Department of Defense who designed the system way back in 1970's. There were many reasons that were cited for the development of a satellite based navigation system. The most important among them was the accuracy required. Earlier navigation systems, which were used primarily by the military didn't used to be too accurate which ultimately used to result in many problems, for example, they didn't had complete idea about their exact whereabouts. This was a dangerous situation to face during wars and conflicts. Another major problem faced was the absence of a proper navigation system. Earlier, we had to depend upon the manual calculations and instincts with the help of maps which used to result in confusions and at times, also getting lost.

These problems were tackled with the ideology of a satellite based navigation system, which can share our pin-point location, and help us navigate to reach our destination.

2.1 Characteristics

GPS on Earth have now existed for over 40 years. To understand the working of GPS on Mars, it is important to know the characteristics of GPS on Earth.

The fundamental concept of GPS is time. Scientists have placed an atomic clock onto the satellite which are synchronized with each other and are corrected from the Earth on daily basis. GPS satellites continuously transmit their

current time and position. The receiver which receives these data then solve certain equations to extract the exact position of the receiver and its deviation from the true time.

There are total of 31 GPS satellites in orbit, of which, at least 4 satellites will always be there in the view of the receiver for it to compute 4 quantities, three will be the position coordinate and one will be the time deviation.

2.2 Orbital Specifications

The space segment (SS) is composed of the orbiting GPS satellites, or Space Vehicles (SV) in GPS parlance. The GPS design originally called for 24 SVs, eight each in three approximately circular orbits, but this was modified to six orbital planes with four satellites each. The six orbit planes have approximately 55° inclination (tilt relative to the Earth's equator) and are separated by 60° right ascension of the ascending node (angle along the equator from a reference point to the orbit's intersection). The orbital period is one-half a sidereal day, i.e., 11 hours and 58 minutes so that the satellites pass over the same locations or almost the same locations every day. The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on the Earth's surface. The result of this objective is that the four satellites are not evenly spaced (90 degrees) apart within each orbit. In general terms, the angular difference between satellites in each orbit is 30, 105, 120, and 105 degrees apart, which sum to 360 degrees.

Orbiting at an altitude of approximately 20,200 km (12,600 mi); orbital radius of approximately 26,600 km (16,500 mi), each SV makes two complete orbits each sidereal day, repeating the same ground track each day. This was very helpful during development because even with only four satellites, correct alignment means all four are visible from one spot for a few hours each day. For military operations, the ground track repeat can be used to ensure good coverage in combat zones.

3. GPS TYPE NETWORK FOR MARS

The navigation system for Mars, which is being proposed in this research paper will be much of GPS module. Mars is the hottest property in space exploration. Due to its distance from Sun, and size, many a times, it has been assumed that there might have been life on Mars at some point or another. With development in technology, the humans reached Moon. Continuous research and technological advancement has now made it possible for us to think of a manned mission to Mars. Many artificial satellites have already been sent to Mars for conducting research of its own and finding the possibility of a manned mission.

In terms of the current U.S. space program, NASA's long-term program Orion has a projected pace of development such that, as of late 2014, human spaceflight to Mars is anticipated in about 2035. That mission will be preceded by shorter flights for the up to four-person capsule involved, with experiments taking place to better the technologies protecting Mars-bound astronauts from the radiation of deep space. But for life to sustain on Mars to conduct efficient experiments and research, apart from the atmosphere, which is must, if there is something that is of utmost importance, it is the existence of proper and established navigation system.

3.1 Advantages

The existence of a navigation system on Mars is of great advantage. If human colony will settled on Mars, it will be important for us to know the path to be followed while exploring new areas of the red planet. Existence of proper navigation and guidance system will help us carry out our exploration and research much more efficiently as we won't have to worry about finding a way back to our base. We can have a well-established path displayed onto the receiver device installed on the spacesuit of the astronauts which can lead them to the base camp. This technology will definitely be a boom as it will help us save a lot of time, which can then be put onto other major things that needs to be done. It will also help us keep track of the astronauts and the base camp from the Earth which can assist the agency in better management of the research work. This system will help us in increasing the the effectiveness of the terrain mapping by providing us with the latitudes and longitudes of the area which can then be utilized by the agencies on Earth as the pin point location for the landing of the Rover on Mars, saving time as well as money. Overall, this technology will be of great help for the purpose of Martian exploration with its overall ability to increase the effectiveness of every mission, as well as assisting us to produce the latitude and longitude location for the planet, which will ultimately help us in easy navigation throughout the planet, which is a very important parameter for us to establish human community on Mars.

3.2 Specifications

This navigation system will consist of 4 orbital plane, unlike 6 required for GPS on Earth. This is because of the fact that the equatorial radius of Mars is nearly 3393 kms while its polar radius is approximately 3373 kms, due to which 4 orbital plane will be sufficient to cover the total surface of the Mars. These 4 orbital planes will have a system of 16 satellites, 4 in each orbital plane. The orbital period of these satellites will be one-half a sidereal day of 12 hours, due to which they need to be placed at an altitude of approximately 20,800 kms after closely taking into consideration the time period required and the mass of Mars. This will enable them to cross the same place or same location every day. This alignment will enable at least 4 satellites to be in the line of sight of a particular place.

The satellites will be equipped with 2 transmitters and 2 receivers. One set of transmitter and receiver will provide the information of the location to the user on the surface of the Mars, while the other set of transmitter and receiver will

transmit and receive data from the ground station on Earth, via a master satellite in orbit around Earth. This will enable us to keep the track record of the complete system from the Earth.

4. CONCLUSION

The research conducted above shows us that if such a system can be implemented on Mars it will go a long way in helping our future endeavors of Martian surface and aerial exploration. It will completely change the way the Martian exploration is seen today as with the existence of location co-ordinates, we can carry out the launches from the Earth to the pin point location on the Mars, thereby developing and increasing the specific area oriented research. It will only lead us to understand the planet in a much better and simpler way.

This project can be further extend to exploring the planet with the help of these satellites by fitting them with specialized sensons and camera which can collect the data about the Martian atmosphere, terrain, climate and other such parameters which can enable the scientists to do a detailed study of the planet before planning a manned mission to Mars, so that every threat is taken care of. The GPS type system will provide the astronauts with the waypoint navigation on Mars, which will help to explore the planet, also creating the possibility of settling humans, thus changing the dynamics of life outside the planet Earth.

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REFERENCES

[1] Daly, P. "Navstar GPS and GLONASS: global satellite navigation systems". IEEE

[2] Agnew, D.C. and Larson, K.M. (2007). "Finding the repeat times of the GPS constellation". GPS Solutions (Springer) 11 (1): 71–76.

[3] Massatt, Paul; Wayne Brady (Summer 2002). "Optimizing performance through constellation management", Vol 3, No. 2, 2002.

[4] McCarthy, D. D.; Seidelmann, P. K. (2009). TIME—From Earth Rotation to Atomic Physics. Weinheim: Wiley-VCH Verlag GmbH & Co. KGaA. p. 266. ISBN 978-3-527-40780-4.