Spatial Computing

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June 2, 2016

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1 Introduction

This document gives a short overview of Spatial Computing. It is an umbrella term for a specific technology which describes the possibilities of working with spatial data types, which are 2D or 3D data types. This technology has revolutionized the way we can work with geographical data. After giving a short description of spatial computing in Section 2 to state what it is in general, Section 3 tells something about spatial computing's development. In Section 4 we have four examples of applications, where spatial computing is applied. Furthermore, we are going to put emphasize on a few advantages and disadvantages in Section 5. Finally, in section 6 a few lines for concluding and ending up our work are added.

2 Short Description of Spatial Computing

Spatial computing is some kind of technology which helps people understanding locations and places and also help them navigating through these. The global positioning system (GPS) might be the most widely spread type of GNSS (Global Navigation Satellite System). This system is used worldwide by taxi drivers, students, farmers for agricultural purpose, tourists and also scientists to scrutinize animal behaviour.[1]

In recent years GNSS also helps finding new tracks to destructed areas after natural disasters e.g. the 2010 Haiti Earthquake and support the inhabitants there. The development of Spatial Computing also helps parcel services to calculate the most ecological route. In this way e.g. UPS was able to save more than three million gallons of gas per year. The amount of different data spatial computing can handle is enormous. It is possible to simulate virtual earth models, develop diverse phenomena, scrutinize the earth' biological circle and understand the environmental physics such as oceans and atmosphere.[2]

3 History

In the 18th century the biggest problem was getting the right longitude. Right after losing sight to land, sailors helped themselves finding orientation with compasses, maps, stars and some type of clock that works on ships which is called chronometer.[3]

The first system developed to avoid the sailors problem was GPS which is the umbrella term of 'Spatial Computing'. It was originally designed for military purposes during the Cold War after 1960. This system was able to track US submarines carrying nuclear missiles in a few minutes. In the beginning of the 1970s the Department of Defense (DoD) wanted to develop such a gigantic system for civil use. The first one was called NAVSTAR developed in 1978. Since 1993 the Global Positioning System is available every time around the world.[4]

4 Types of Spatial Computing

4.1 Global Positioning System

The Global Positioning System is a huge network with an enormous amount of satellites, which belongs to the US - Government. These flying objects send some specific information to earth which can be handled correctly by a GPS-receiver. The amount and type of information depends on the version of the GPS signal. Actually there are two different types of versions (SPS[Standard Positioning System] and PPS[Precise Positioning System]). The first one sends data with the so called L1-frequency and gets used in civil, commercial and scientific purposes. The second one uses L1 and L2 frequency and due to the accuracy the PPS is only made for and used by the US-Army.[4]

The GPS Signal provides information such as location and time. Former consists of longitude and latitude. These two sub informations can be written in different formats but the most popular is the one with degree, minutes and seconds. E.g. N52° 31' 14.941" E13° 24' 34.020" is a specific coordinate where N stands for latitude and E stands for longitude. The better the connection between transmitter and receiver (dependent on the number of available satellites) the more precise the position gets. The duration until the information reaches the earth is about $6/100^{\text{ths}}$ seconds. Each satellite broadcasts information at a speed of 50 bits/s. When the signal gets back the actual height of the receiver can be computed.[5]

Nowadays the GPS System is widely used in almost every smart phone, tablet and car stereo.

4.2 Remote Sensing

Remote sensing is used to find out how much area is covered by forest or to see the recent terrestrial changes. In the old days these things had to be done by hand but nowadays the Remote Sensing system can check and process such things.[3] The biggest advantage of this technology is the possibility of collecting data in dangerous and inaccessible areas. There are different technologies for Remote Sensing. Either light is used which gets absorbed e.g. by a forest, light gets sent to the satellite and afterwards to a ground station. Another technique is sending frequencies to the ground and back again to satellite, afterwards these informations get transferred to a ground station. For the second type of checking natural areas ultrasound sensors can be used to measure the amount of forest in a specific area.[6] With this amount of crucial data Google invented a new System, named Google Earth Systems.[3]

4.3 Spatial Database Management System

In the Last few years, the need of storing spatial data grew, because science had problems with storing images, pictorial data, geometry data and many other data types.

Therefore it was necessary to create a database for storing this data types. The several attempts to store such data in relational database systems led to no useful result.[7] The creation of the spatial queries in relational databases needed a high amount of programming, because of complexity. However, also

the times of computation were long, because of the mismatching of 1D data types with 2D spatial data types.[8]

Spatial database systems became popular, when the "Symposium on Large Spatial Databases" started thinking about a database, which contains sets of objects instead of pictures or images.[7] Nowadays, spatial databases implement spatial data types, spatial data structures and operations to efficiently store spatial data and represent spatial queries. The development of this spatial databases result in reduced programming effort and fast response times.[8]

4.4 Spatial Statistics (Spatial Analysis)

In the late 19th century it was a big problem, when scientists wanted to present information on a large geographic area, because they were not able to do that on big areas. They had to put the information manually on a map, so it needed a large amount of time to create something like that. Today big corporations use spatial statistic to present a big variety of information, not only geographical data.[9]

There are several areas and techniques to use spatial statistics, also called spatial analysis, and many of those areas are still in development. It is very useful if you want to investigate hotspots of geographical data. Thus, spatial statistics is very popular in public health.

People know that if they put various information together, then it will create something with new information. This is used e.g. in public health. If you collect different places where a disease breaks out and put them together on a map, then you will maybe find information about the cause. This knowledge was made, when Dr. John Snow, who lived in London in the 19th century, created a map, where he forms cluster at the places of cholera deaths on a map. With this map he wanted to show that the outbreak of this disease is related to a special place.[10]

To sum this section up, spatial statistics is very helpful to obtain new information with clustering existing information. With the techniques today, we can apply this on large areas.

5 Advantages & Disadvantages

In this section we want to present some of the important advantages and disadvantages of spatial computing.

Most Advantages are clear, when you read the lines above, but i want to summarize and put emphasize on a few. It is clear that, spatial computing was an important factor that GPS is so popular and available on so many different devices today. For the support on such a variety of devices, it was essential to create structures for storing and working with this special types of data, especially spatial databases and spatial analysis.

In Addition, one of the most powerful advantages of spatial computing resulted in the development of the OpenSPL (Open Spatial Programming Language). With this programming language, experts are able to generate optimal structures, which help to increase the efficiency of Spatial Computing. A great benefit is the ability for reducing the carbon footprint. In times of global warming, this is one of the biggest advantages.[11]

A big disadvantage of GPS is that many people are insecure if they should use applications which track their position. On the one hand, GPS is very useful in many parts of our live, but on the other hand people worry about lacks of geoprivacy.[12]

6 Conclusion

Concluding, this paper gives a short overview of the most recent techniques and application areas of spatial computing. The information above gives a brief introduction for people, who are not aware about the big contribution to our technologically advanced life, which is given by spatial computing.

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