GPS for Global Performance System

new aspects of time and space in art

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Abstract
The following text presentation of computer system dedicated for outdoor interactive activity. GPS receiver, the engine of the system, describes object position and follows it's motion in 3D space (with the only limitation to the satellite signal, so practically avaiable on the whole surface of the globe). The use satellite signal opens new applications of the interaction, not available through recent methods: video, photocell, infrared, ultrasonic systems. First of all it works for long distances in „invisible" manner. It is also quite precious working with high resolution (several meters). It is specially usuefull for large scale outdoor spaces (urban projects), as well as can be used as an extension for the short-distance systems

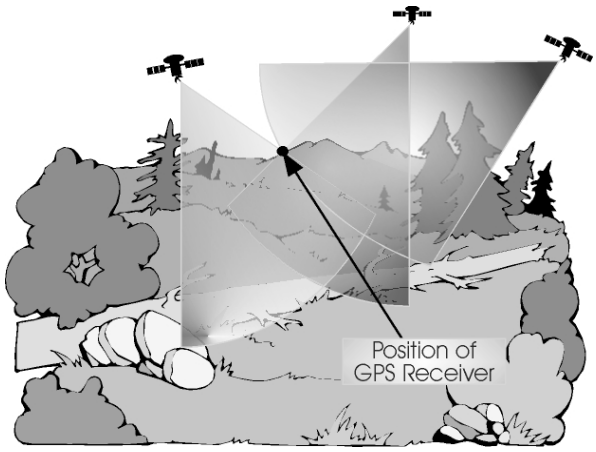
INTRODUCTION
The first GPS application for interactive artistic purposes was designed during ArtBoat environmental project in 2000. The idea was to measure the position of the boat sailing on Vistula River, it's speed, distance to the bottom of the river, temperature of water and air, speed of wind, light during night and day (with, or without clouds). All these natural parameters are translated to the sound sequences performed live during whole project in one of the cabin of the boat. In fact it was designed as a giant sound installation controlled by natural parameters of the boat.

Seeking for the best method of the boat scanning, we've considered GPS device used mainly for navigation purposes. Choosing GPS device as a main sensor for our art projects, we introduced new field of art exploration called GPS-Art. We founded also the basic idea of a large scale art exploration. Confirming the official regulations in American law on May 2, 2000 according to the range of the GPS frequency band available for civil purposes (Selective Availability) the range resolution decreased from 100 m to 15 m. Another official regulation stabilizing use of GPS was confirmed on ICMC conference held in Berlin in 2000, partly considering interactive purposes. Most of the projects were dedicated to extended space and higher resolution and precision of interactive systems. [vide: ICMC Proceedings, s 138]. There is an obvious contradition to both thesis, so most of the projects presented on ICMC in 2000 were kind of compromise between 2 factors.

GPS System works on large scale (whole globe) with high resolution (some of the system up to 3 m).

Basics of Global Positioning System

Basic idea refers to the measurement of the distance between receiver and several satellites choosen from 24 going around Earth 2 time for 24 hours. Particular orbits of satellites, their direction and speed are preciously aassigned. There is an exact 24-hours schedule assigning the time and space position of the satellites stored in ROM memory of each GPS unit. The measurement is a permanent process comparing incoming signals with the information stored in a memory of GPS unit. Time distance of incoming signal multiplied by by the speed of the signal describes distance from the satellite. Comparing distance from at least 2 satellites GPS is able to assign it's own position. Considering precision of electronic clocks used in civil GPS devices and comparing them with the precision of the satellite's clock we have to make a correction using at leat one extra satellite.



Measurement from 3 satellites (2-Dimension Navigation) gives an horizontal resolution of 10-20 meters and vertical resolution of 20-80 meters. Measuring signal from 4 satellites we are obtaining 3-D resolution. More satellites for simultanious measurement increses the resolution of the system. Testing Garmin GPS 12 I was checking 9 satellites (quite typical for Europe) I was obtaining EPE (Estimated Precision Error) of 3m resolution and making long-term measurements with resolution of 10m.

Currently available resolution of GPS is too small to obtain measurement s of a small motion of different parts of the body (gestural controll) but can be used succesively in a range of several meters on stage. However the main application of GPS lays in bigger scales of kilometers and it is the only device working in

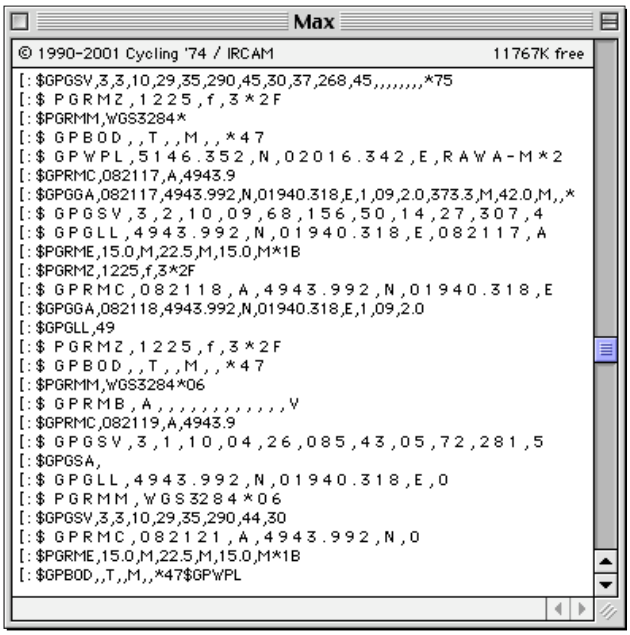
such a cirmustances, measuring the movement of car, boat or airplane. Working in large scale fields the resolution of 3 m is relatively very small.

There is a chance to decrease the error of measurement below 2 m using DGPS (differential GPS). It is an cuircut of 2 receivers. One of them is fastened to preciously assigned position. The second GPS is moving receiving signal from satellites and from the first receiver. Additional signal from preciously assigned place lowers the resolution of EPE to 2.1 m. DGPS system will be replaced between 2003 and 2013 by a new III GPS systems, using new frequency bands (besides current -- L1, L2 till 2005, and L5 till 2012) and new transmission codes (M code). Another solution is a new concept of WAAS (in Europe known as EGNOS) using series of extra stable transmitters (DGPS units with large access). The system will be ready in 2008. Use of III GPS will be visible in form of 1 m resolution and translation of each movement of the performer on stage.

NMEA - how to get connected with computer

In 1980 National Marine Electronics Association assigned firs standard of data transfer between electronic devices. Nobody considered the connection between GPS and computer, the NMEA 0180 protocol was used to combain loran (device informing about deviation of the main course) with autopilot. So both, NMEA 0180 and 0182 was used only for the deviation from the main course of data transmission. In 1993 NMEA 0183 version 2.0 extended several instructions describing course parameters (point position, latitude, speed etc) and the information about wheather parameters: wind, temepature, air preasure.

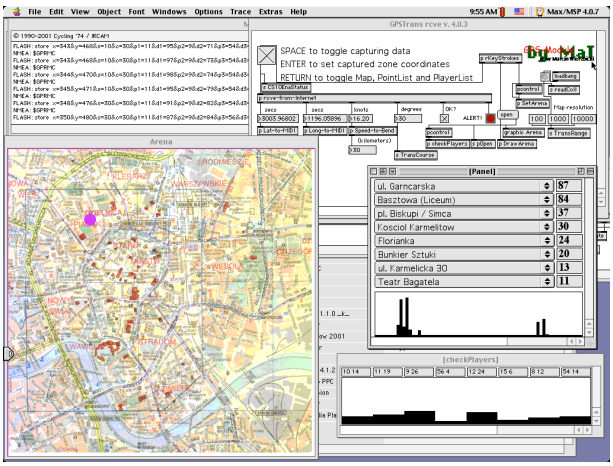
Inteface NMEA is quite close to RS-232 – serial port used in computer world. But it works with different protocol – EIA422, what is the main obstacle. We can not connect typical modem with GPS, there are certain technical problems using typical serial port of Macintosh computer. With extraction of pin 9 it is possible (all details you can find at www). GPS connected with interface NMEA 0183 2.0 with 4800 baud speed and 8-bit 1 bit step/odd will transmitt NMEA data in form of ASCII codes, where each data enters by $, 2-letter symbol assigning type of device: GP – GPS, LC – Loran-C, 3-letter mnemonics (i.e. RMC – Recommended Minimum GPS, GSV – Satellites in View) and series data fields interconnected by comas. Standard uses data with variable length and makes gaps of unncessery data, the leght of particular message (and fields of data inside) is not constant. It means that the only correct form of NMEA message interpretation is commas counting (not symbols), in In case of lack of the symbol empty space is calculated by commas. Each message looks as follows <CR><LF> anticipated (optionally) by symbol * and 2-bytes (in hexadecimal form) control sum of message (XOR).



Max Implementation

With exact description of NMEA protocol we are able to realize an application, which can read GPS data on serial port, make interpretation and processing.

Our main project is an musical one, so we decide to use Max program to operate GPS. Entirely we created a simple interface receiving message $GPRMC (Recommended minimum specific GPS/Transmit data). from Garmin GPS12. This message is sent every 1 sec. It includes basic georgraphic parameters of the object, speed, course, current date and time and warning if receiver is out of the satellite access. Reading and interpreting all those parameters was the entire position for our project GPS-Trans 2. The basic idea was to follow a car moving through the Krakow city, receiving it's position and generating musical phrases. In this very moment we've got propblem with wireless communication.



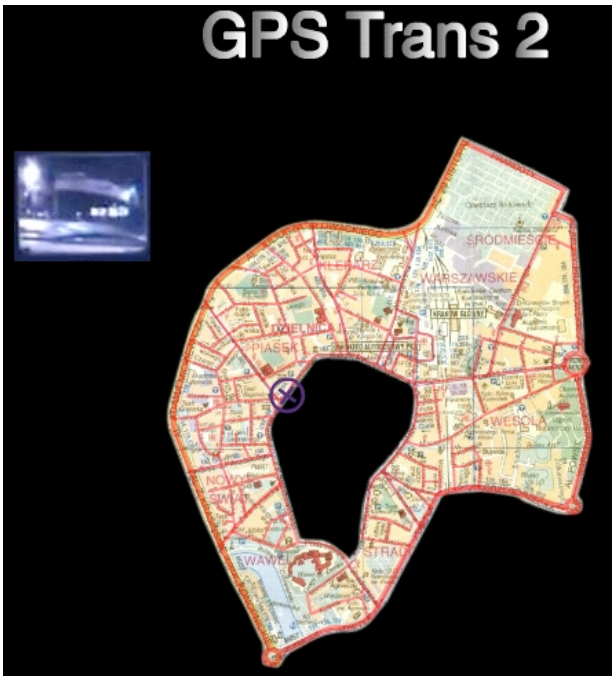
Receiving NMEA Stream Wireless

The portable musical system consisting laptop computer connected with GPS-unit was not hardly installed in a car. But to invite audience in the same vehicle was another chalange, even with the idea of a bus rent. So the only solution was to use a wireless system of communication able to send signal from a moving car to the auditorium. With the use of mobile, wireless cellphone we were not able to send an audio signal. Transmission speed of 9600 baud was too low, but was fast enough to send NMEA data. Finally we created a GPS-Phone hybrid system combaining GPS 12 unit, PowerBookG3 laptop computer and Ericsson mobile phone. The additional advantage was the fact that the laptop computer was filtering, interpreting and transitting data from GPS to specific Internet address. , Transmission was realized using UDP (TCP/IP) format supported by external objects of Max written by Matt Wright (CNMAT, Berkeley).

Max objects were designed to be quite stable. Mobile phone was connected to the computer through serial cable (even IR transmission was considered, tested with quite good results). In the same moment all data were receiving by computer system in a Studio of the Krakow Academy of Music. In this form the car was the performer of the audiovisual piece and GPS kind of interface controlling position of it's movement.

Past Projects: GPS Trans 2 & 3 – artistic idea

Interactive city map appearing in front of the audience was the main principle of GPS-Trans. Center of Krakow was divided for 41 zones. Each zone was connected with selection of pictures. 68 special points-centres was connected with series of prerecorded audio samples representing different regions of the city. Exploration of the car was interactivelyu synchronized with different regions of the city, triggering and controlling series of images and samples. Player module was designed in a way that the car was playing up to 4 (in GPS-Trans3 up to 6) sounds/samples with the volume level reflecting the distance to certain point. The result was the ilussion that we are all coming closer or getting out of certain regions of the city. In Trans 3 we add the speed of the car contriolling transposition of the samples and the frequence of the images rotating on the screen. As a result we were getting illusion of the real speed of the car.

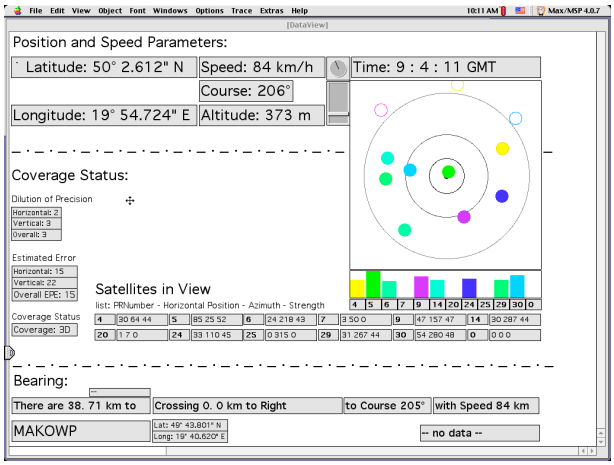


Another principle was to create wide access to the audiovisual map of Krakow. Internet was just the right choice. Our decision was to make audiostreaming from Max program to RealPlayer and from Max to Flash (for slide-show). Both transmissions were essential for all web observers/receivers.GPS-Trans2 had quite limited response. GPS Trans 3 was an international project and was a part of Internet project Cathedral composed and coordinated by William Duckworth and during this project was available everywhere on the globe through 2 hours ongoing Internet transmission at www.gps.art.pl. In this way Krakow city was explored and presented everywhere using such a very sophisticated and original method of art creation.

Future Projects. ArtBoat and other

Every year we are trying to realize ArtBoat project.. Currently designed NMEA Interface written in Max is an universal tool receiving position of the object, distance to the target, latitude, position of satellites and other data as a complete set of messages of Garmin GPS12. Interface has an open structure, which means that we can add interpretation of new messages , for example MTW (water teperature) , VHW (speed of the water), VWR (speed of the wind), DBT (distance to the bottom of the river). All those parameters can be measured and interpreted to the musical applications.

Quite interesting artistic results we can obtain using oposite methods. Instead of measurement of object position we can check position of satellites. Their trajectories are constant. In case of long-term, continues sound structures, long-time projects, the position of satellites can be an advantage and can be used with a big success. Another factor is connected with the power of the signal from satellites, limited and filtered by cluds, buidings, tries, which are covering part of the beams of the signal from satellites.



Additional idea is connected with the feedback response from the listener(s)/observers on Internet. We were considering one-way transmission of data from the car to the serwer. We can also send data to the car, so the response from any computer connected with the web is possible. In fact we can send the message to the driver with certain idea to speed up, or slow down driving. In this case we are quite close to the Reality Game idea with the full form of interaction [ICMC Proceedings 2000, s.117-120]

Another idea of GPS GlobalMix is a kind of performance for many participants using independent GPS devices. It seems to be quite complicated from technical point of view but the current dynamic development of many devices make this opportunity quite possible. We have already access to the PCMCIA GPS cards , GPS modules to the PalmTops, as well as cellphones with build-in GPSs. Simple NMEA protocol is another bridge to many applications, Max, Pure Data and PDA among others.

Troubleshooting

We solved most of the problems with receiving, transmission, ineterpretation of GPS signal, as well as the right music translation. All new concepts are not easy, but opne structure of the system seems to be unlimited. System works fine in all open spaces, even quite limited. The chasis of the car was not a real problem. One of the biggest problem of GPS is indoor space. It seems to be an basic problem, so the best idea is to confirm the limit. Another problem is resolution of the system.

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There is temporal problem. So in a near future we will be able to realize most advance interactive project with the use of GPS. J [vide: ICMC Proc.2000, s. 129-132, s. 138, s. 141-144].

There is unlimited access to the GPS devices. There are mounted in cars, cellphones, boats, airplanes. They are smaller and cheaper, so avaailable.

CONCLUSIONS

The civil use of GPS system is improving quite quickly. In a near future it will be available for general interactive projects any kind. The documenation of different models of GPS is available.

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