

GROUND-BASED LASER POSITIONING

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ABSTRACT:

The part of MICOS was to realize a positioning system for the ground-based positioning of a laser scanner. The positioning system should provide a very precise horizontal and vertical initial leveling of the laser measuring system as well as determine the absolute position of the measuring system with reference to an inertial system of coordinates. Out of several mechanical possibilities we finally decided to use a frame construction with pushers (pushing drives). The positioning system is controlled by a stand-alone computer, communicating with a laptop via wireless connection. This laptop controls the complete scanning system which consists of the laser scanner and the positioning system. Additional components are a sensor of inclination, an electronic compass and a GPS-mouse. These parts are used for referencing the scanning process.

For the scanning process itself, you need the scanning software of the company Z+F. By starting the scanning the leveling process will be done automatically and the data of the components of the positioning system will be read out and saved. Now the scanning of the environment itself starts. After scanning the component data will be stored again, in order to compare them with the beginning initial data and to recognize a sinking of the system into the soft ground.

KURZFASSUNG:

Die Aufgabenstellung war es, ein Positioniersystem für die bodengestützte Positionierung eines Laserscanners zu realisieren. Dieses Positioniersystem soll eine hochgenaue horizontale und vertikale Initial-Ausrichtung des Lasermeßsystems bewirken und gleichzeitig zur absoluten Positionsbestimmung des Meßsystems in Bezug auf ein inertiäles Koordinatensystem dienen. Aus mehreren Varianten der Mechanik kristallisierte sich schließlich eine Rahmenkonstruktion mit Pusher-Antrieben heraus. Die Steuerung erfolgt über einen eigenen Rechner, der über eine Funkstrecke mit einem Laptop kommuniziert. Weitere Komponenten für die Ausrichtung des Systems zur Referenzierung sind ein Neigungssensor, ein elektronischer Kompass und eine GPS-Maus.

Der Scanvorgang läuft folgendermaßen ab: Für die Steuerung des Gesamtlaufes ist nur die Scannersoftware der Fa. Z+F notwendig. Mit dem Start des Scanvorganges wird automatisch die Nivellierung ausgeführt und die Daten der entsprechenden Komponenten des Positioniersystems ausgelesen und abgespeichert. Erst jetzt beginnt der eigentliche Scanvorgang des Umfeldes. Nach dem Scanvorgang werden erneut die Daten der Komponenten ausgelesen, um einen Vergleich mit der Startbedingung durchführen und so ein Absacken des Gesamtaufbaues erkennen zu können.

1. TECHNICAL REALISATION OF GROUND-BASED LASER POSITIONING

1.1 Introduction

Our part in the NATSCAN- project was to realize a tool for a laser scanner which is used for taking stock of the forest. With the help of our positioning system the laser scanner will automatically be aligned horizontally before the measuring starts. The output data of an integrated GPS-module define the position of the tool in an inertial system of coordinates. An electronic compass provides the information about the direction of the laser scanner.

1.2 Mechanical solution concept

Three concepts to design the mechanical solutions are possible.

The first idea was to use a two axis goniometer, a system with two different goniometer stages and one common turning-point. For this solution the stiffness is not enough for

the weight of the whole assembly. It is also worth mentioning that this set-up would be much more heavy than the final solution.

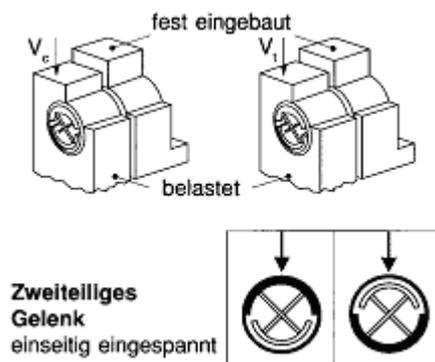


Figure 1. Crossed-Flex-Bearings

The second possibility we thought about was a frame construction with belt drive. The system with the belt drive solution is not accurate enough to get the required specifications. Advantage of the belt drive would be the speed but the resolution and the bi-directional repeatability are not acceptable.

The solution we built up at the end was a frame construction with pusher drives. The construction is similar to an oversized gimbal-mount with Crossed-Flex-Bearings (see figure 1).



Figure 2. Picture of the pusher MA-35

These Crossed-Flex-Bearings have several advantages. Because they operate without friction and don't need any lubrications, they are maintenance-free. They are insensitive against contamination, they don't show fatigue and have therefore a high expectation of life.

For the motorization we preferred two gear-head DC-motor driven pushers (see figure 2) made out of stainless steel material and spherical rolling joints. The frame construction consists of a special tempered aluminum alloy we normally use for our precision linear stages. The design of the frame was a compromise between lightweight construction and stability of the set-up. The Crossed-Flex-Bearings are excellent for the accuracy of the set-up and have also the advantage of no abrasion. In addition to that they are very stable against vibration, a problem for all "mobile-measuring-systems". The pushers are built in a 90° arrangement with two ball-and-socket joints to realize movements in two degrees of freedom. The other side of the pusher is fixed with a fork link. The actual travel range of the pushers (see figure 2) is +/-25 mm, but for this project only a travel range of +/- 17 mm is necessary to achieve the required +/- 10 degrees. In this special geometrical arrangement, there is an almost linear relationship between the distance in mm which the pushers are moving, and the angle in degrees which the platform finally moves. This makes the leveling much easier compared to a system with a nonlinear relationship.

Figure 3 shows the complete setup of the laser scanning system. At the bottom you see the tripod and nearby the computer. Mounted on the tripod is the ring with the tilting mechanism. Connected to the ring is a bride which contains the electronics (MoCo, sensors) and serves as support for the laser scanner.

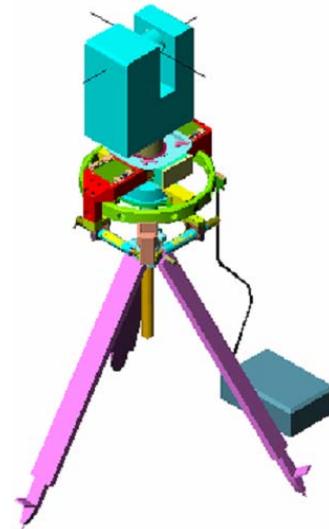


Figure 3. complete laser scanning system

1.3 Electrical solution concept

For the realization of the motion control part, two different concepts have been taken into account. One concept uses one controller (e.g. PC-board) and one power drive for all motors. The other concept is a decentralized one, it uses one single-axis controller for each motor. In this case the controllers are connected with a bus system.

For this project, we have chosen the second concept which was realized with MICOS MoCo controllers. The MoCo controller (which is used for each pusher) fulfils the requirements of the project and combines high resolution with a low price. It is lightweight and compact and can be easily integrated into the positioning system.

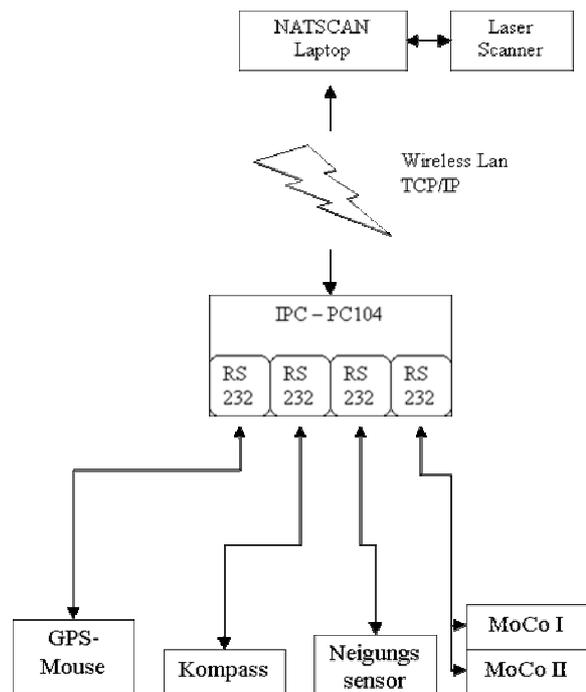


Figure 4. scheme of the concept

Due to the high number of devices which have to be connected to a PC (MoCo controllers, sensor of inclination, electronic compass, GPS-mouse, laser scanner), we decided to use two computers instead of connecting everything to one single computer. One computer is the master, this master computer (laptop of the company Z+F) controls the laser scanner as well as the slave computer. The slave computer is responsible for the MoCos, the sensor of inclination, the compass and the GPS-mouse. This computer (a PC104 computer provided by MICOS) is used as a black box, it has no keyboard or display, the communication is done by TCP/IP connection and a special command language from the master PC. To reduce the number of cables, the TCP/IP connection is done with a wireless LAN system instead of a standard patch cable.

The advantage of this concept (see figure 4) is that the master PC is free from all the communication tasks which saves resources.

1.4 Conclusions

Based on the experiences with the current demonstrator, it seems that the solution concept fits all the requirements of this project. The prototype can generally be realized with this concept, but a small number of detailed improvements should be done to implement the experiences made until now.

The prototype should also contain the experiences from the other partners of the project, for example the adapter plate between the laser scanner and the platform can be optimized to ensure a defined alignment in north direction.

The absolute accuracy of the whole system can be improved by using a more sophisticated but also more expensive GPS receiver. Differential GPS is recommended because it provides a much better accuracy. Also considered should be the increased scanning angle of the laser scanner, the mechanics in the current demonstrator is designed for the previous smaller angle so that at the edge of the scanning range some pieces of mechanics are scanned. This can be taken into account in a redesign of the demonstrator.

With the help of high tech materials further weight reduction is possible.