27. SIMPOZIJ AKTUALNI ZADACI MEHANIZACIJE POLJOPRIVREDE

UDC 631.373:621.37
Prethodno priopćenje
Preliminary communication

EXAMINATIONS ON A MICROWAVE VELOCITY SENSOR BASED DEAD RECKONING SYSTEM FOR IMPROVED POSITIONING OF AGRICULTURAL VEHICLES WITH GPS

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SUMMARY

For bridging shading effects and other faults of GPS a dead reckoning system is needed. The Institute of Agricultural Engineering of the Technical University Munich examines a system, that is based on microwave velocity sensors in Cross-Janus configuration. Available microwave velocity sensors with one and two beam technology are used.

Key words: *GPS, localization, navigation, dead reckoning system*

INTRODUCTION

During the change of the homogeneous cultivation of agricultural towards precision farming, the navigation and positioning of vehicles has to play a decisive role. Present positioning systems are used for yield mapping and for soil sampling. Further, they are used in the case of the spatial variable fertilizing and plant protection (picture 1). A higher accuracy and reliability of the available satellite positioning systems would promote a wider acceptance of this technology and may improve the cultivation of crops regarding to costs/yield and to environmental protection.

"Precision Farming" makes the collection precise information possible, allows a precise work and run local applications, as shown in picture 2. Results are the automated data acquisition, the adjustment/control of machines and implements and a site specific crop production.

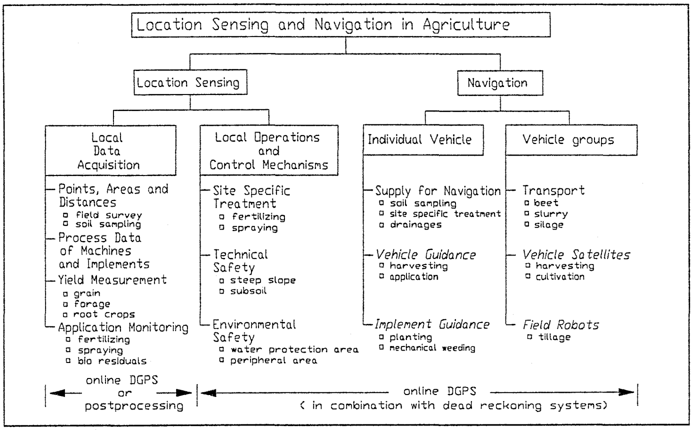


Figure 1. *Usage of location sensing an navigation in agriculture*

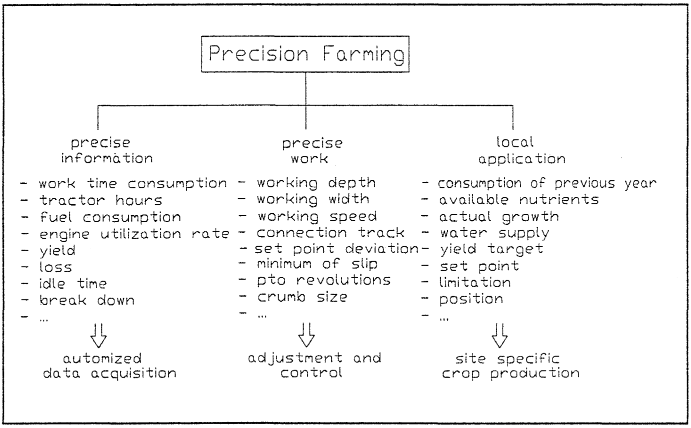
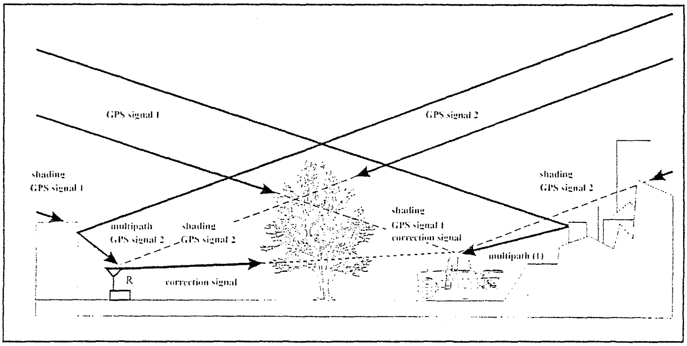


Figure 2. *Sections and items of "Precision Farming"*

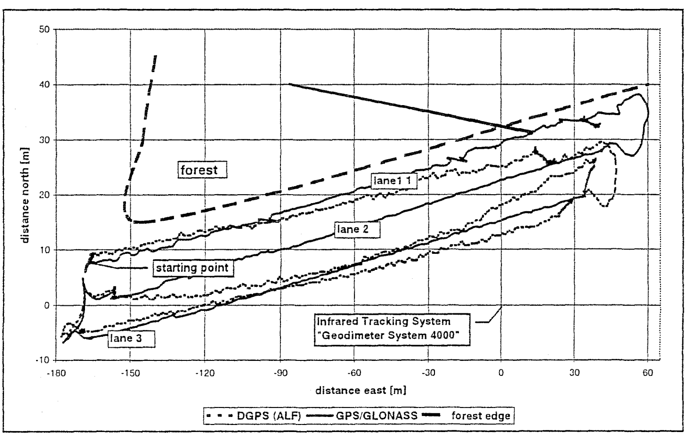
PROBLEM

A central problem of the satellite navigation and positioning is the lasting availability of the signals and its reliability. During the localization and the navigation by means of GPS, shading and multipath effects can occur. Shadings occur from the fact the direct line of sight connection to the GPS satellites is not given. Also multi path effects through refraction and reflection of the GPS signal are possible. These effects are responsible for a reduced accuracy of positioning and/or for the total breakdown of localization.

Picture 4 shows rides on determined lanes with two GPS systems at different distances to a forest edge. Lane 1 on the forest edge with the greatest shading also shows the greatest positioning error. Lane 3 at a distance of approx. 15 m of the forest edge reflects the actual going process well.



Picture 3. *GPS shading and multipath effects*



Picture 4. *GPS shading on forest edge*

SOLUTION

Microwave sensors with one or two beam technology have been examined as sensors for a dead reckoning system. Investigations showed, that the used microwave systems are quite suitable for touchless and free from slippery velocity and track measurement with high accuracy under difficult agricultural conditions.

The studies are divided into two parts.

In a testing stand, in which most vehicle movements can be simulated, the investigations of the Cross-Janus configuration take place. Calibrating runs were made and the behavior of each sensor on different movement expiries, various speeds, mounting angles, mounting position and different grounds is examined and evaluated. As reference system a Infrared-Tracking-System "Geodimeter System 4000" was used.

The testing stand results are evaluated at a tractor with a front mounted measuring frame or a measuring cabin in rear. In these experiments, the data of the microwave sensors and from the GPS are parallel recorded. As reference system again the Infrared-Tracking-System "Geodimeter System 4000" was used. The tests have been made in geometrically determined lanes on a measured test area. The traces run at different distances and parallel to a forest edge, representing shading problems and to be able to examine behavior of all microwave sensors. In further experiments, only circular rides have been made, where the main attention was put to the sensors facing to the side.

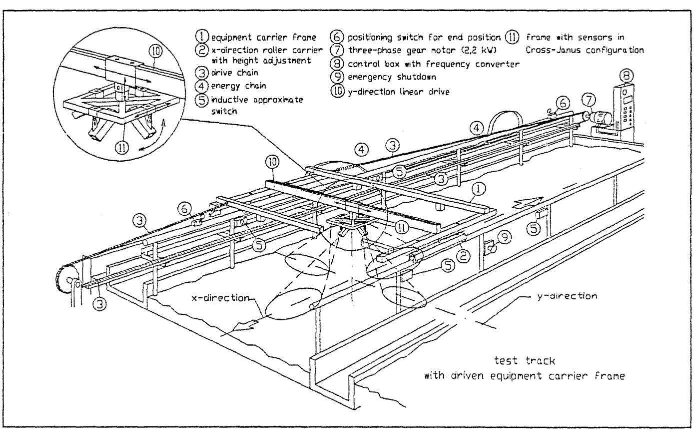


Figure 5. *Microwave sensors testing stand*

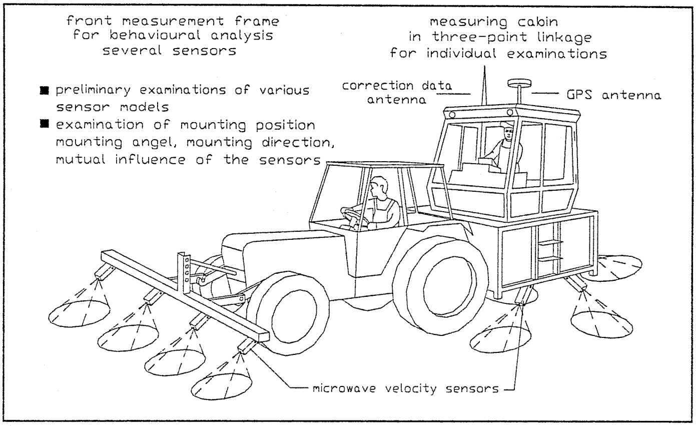


Figure 6. *Configuration for practical tests*

RESULTS

The investigations show, that the driving path can be measured with microwave velocity sensors in the used Cross-Janus configuration. Problems are caused by the crossways sensitiveness of the sensors.

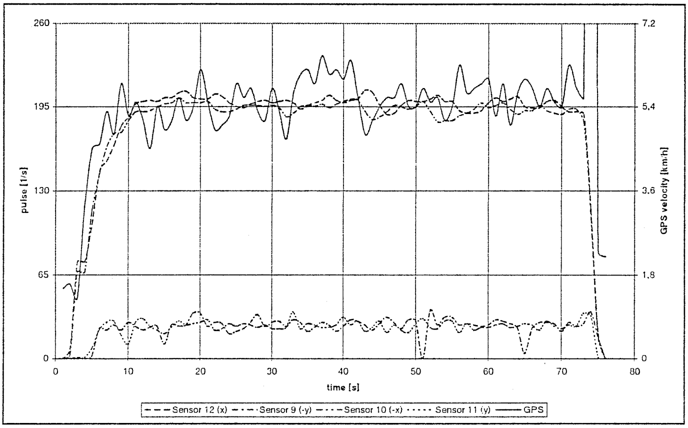


Figure 7. *Velocity measured by GPS and microwave sensors on lane 3*

Movements vertical to the real beam- and measurement direction are also registered, e.g during curve rides. In picture 7, a comparison between DGPS (with long wave transmitted pseudo range correction signal ALF), sensor 12 in driving direction, sensor 10 towards the driving direction, sensor 9 to the right and sensor 11 facing to the left in driving direction, velocity raw data for a measuring ride parallel to the forest edge is shown. The data output of the microwave sensors occurs in pulses/s where 130 pulses/s correspond to a velocity of 3,6 km/h. The bad quality of the DGPS signal and the good play-back of gone velocity is to be recognized very clearly by sensors 12 and 10. Sensors 11 and 9 also register a velocity which however is not real but which can be evaluated as a interference source of velocity into driving direction. This interference source is based on the crossways sensitivity of the sensors which can be reduced by suitable shielding to change the footprint and in the case of sensor 9.

Picture 8 shows a ride on lane 1, which courses directly on forest edge. The shading effects are visible by the varying GPS velocity although the tractor had a constant speed. A changed footprint on sensor 9 reduced the crossways sensitiveness and the measured velocity in vertical driving direction. To change the footprint a shielding with microwave absorber materials was used.

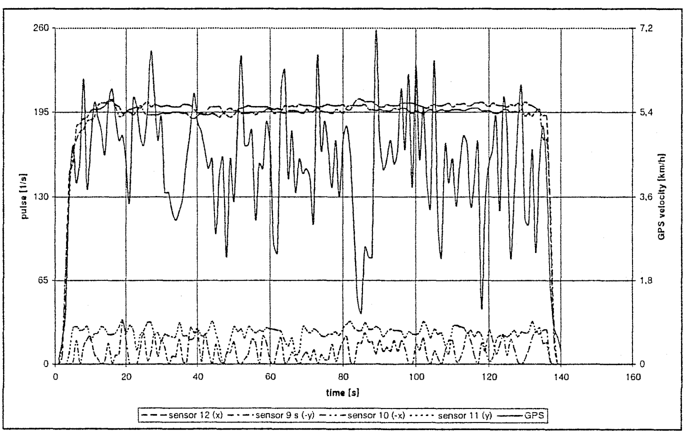


Figure 8. *Velocity measured by GPS and microwave sensors on lane 1, sensor 9 footprint changed*

The shielding on sensor 9 doesn't influence the behaviour in the real beam and measuring direction. Picture 9 shows clearly, that the measured velocity in a right turn by sensor 9 are smaller then these by sensor 11.

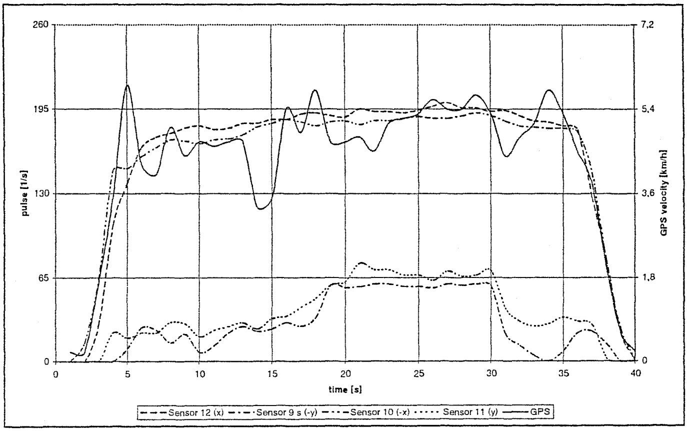


Figure 9. *Velocity measured by GPS and microwave sensors in a 180 degree right turn, sensor 9 shielded*

CONCLUSION

For improvement of the accuracy of the microwave sensors positioned to the side, further investigations with regard to their crossways sensitiveness are needed. Subsequent studies in the test stand will concentrate on the registration of the nodding and rocking movements occurring in practice. These movements can be calculated by mathematical relations with the aid of sensors 10 and 12 and/or 9 and 11. Present tests take place with four identical microwave velocity sensors. It is further planned to make an examination of all available sensors.