ANTICOLLISION ALGORITHM FOR V2V AUTONOMUOS AGRICULTURAL MACHINES

ALGORITM ANTICOLIZIUNE PENTRU MASINI AGRICOLE AUTONOME TIP V2V (VEHICLE-TO-VEHICLE)

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Abstract: *On the present more and more world food quantity demands, the role of the agriculture machine producers is very important trough the permanent target to improve the functionally and operationally capacity of the agricultural machinery system to can achieve the proposed goals of increasing the agricultural productivity and also to can make possible the application in agriculture of the newest technologies. From human labour, through animal power, to mechanical power - agricultural machinery systems have evolved to meet the challenge but this continue development has been fuelled by a need to increase productivity, reduce human drudgery, and decrease peak labour demands.This paper evaluates (by analogy with the systems developed or developing related to road traffic) a comparative analysis of different systems of command and control and proposes a simple algorithm to avoid accidents by two or more autonomous agricultural machinery. The algorithm was developed and will be implemented in future phases of research and is based on the use of functions of GPS (Global Positioning System) integrated into the computer systems of command and control. It is also the first national study by addressing, and implementing research results in agricultural autonomous machines.*

Rezumat: *In conditiile actuale a cresterii cererii din ce in ce mai mare a produselor alimentare la nivel mondial, un rol important este detinut de perfectionarea continua a functionalitatii si capacitatilor operationale a masinilor agricole, prin aplicarea si adoptarea celor mai noi tehnologii disponibile. Incepand cu munca fizica umana si/sau, utilizand forta animala s-a ajuns la sistemele mecanizate prezente, care au evoluat in timp in scopul cresterii productivitatii, reducerea efortului uman si atingerea obiectivelor cerute de culturile agricole.Lucrarea prezenta evalueaza (prin analogie cu sistemele dezvoltate sau in curs de dezvoltare ce tin de traficul rutier) o analiza comparativa a diferitelor sisteme de comanda si control si propune un algoritm simplu de evitare a accidentelor de catre doua sau mai multe masini agricole autonome. Algoritmul a fost creat si urmeaza a fi implementat in cadrul unor viitoare etape de cercetare si este bazat pe utilizarea functiilor sistemelor GPS (Global Positioning System) integrate in cadrul unor sisteme computerizate de comanda si control. Lucrarea este de asemenea o premiera pe plan national prin abordarea studiului, cercetarii si implementarii rezultatelor obtinute in domeniului masinilor agricole autonome.*

Key words**:** *autonomous agricultural machine, collision, algorithm, GPS systems.*
Cuvinte cheie**:** *masini agricole autonome, coliziune, algoritm, sisteme GPS.*

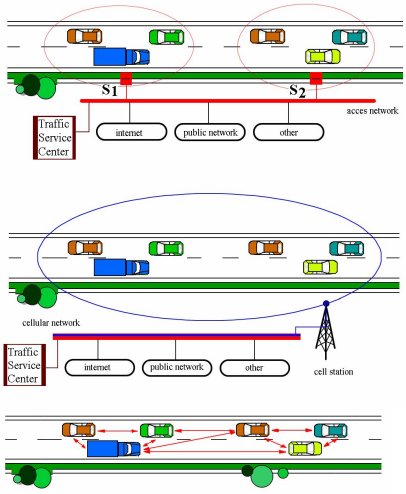
INTRODUCTION

One of the future directions in agriculture in order the follow desiderates (to increase productivity, reduce human drudgery, and decrease peak labour demands) is that the extensive use of autonomous agricultural machines (AAM) in particularly, the specific of agricultural technologies and processes. Research in this area are very well developed and supported financially in the United States and Japan, unlike Europe where the research (and especially the practical applications) are modest [4,5].

Condition required to be imposed in the development of autonomous agricultural

machines is to avoid possible collision between them, taking into account the typical (particularity) technology, a process of mechanized agriculture (simultaneous use of several agricultural machines).

Development of inter-vehicular communication for autonomous agricultural machines can realize the results already obtained in road transport. Thus, currently, there are three main directions of research and development in the field (figure 1).



⇒ Dedicated infrastructure

⇒ Cellular networks

⇒ Direct vehicular communication (V2V)

Figure 1.Vehicular communication systems

Table 1

Comparisons between vehicular communication systems

Parameter to consider	Vehicular Communication		
	Dedicated infrastructure	Cellular networks	Direct vehicular communication (V2V)
Communication latency	medium	high	low
Link availability	medium	low	high
Data exchange rate	medium	low	high
System availability - local - global	 high low	 high medium	 high high
Flexibility of connection	low	low	high
Costs - initial costs - operational costs	 high medium	 high high	 low low
Area services	medium	large	medium
Support for autonomous agricultural machines applications	medium	low	high

Taking into account the specific conditions of agricultural work can be said that for developing autonomous agricultural machines, the most feasible approach is to use the inter-vehicular communication V2V (Vehicle-to-Vehicle).

In the V2V system (figure 2) vehicles mutual information is transmitted in real-time information about speed and position via a data protocol (figure 3) proposed and developed by CHISALITA et. al. [1].

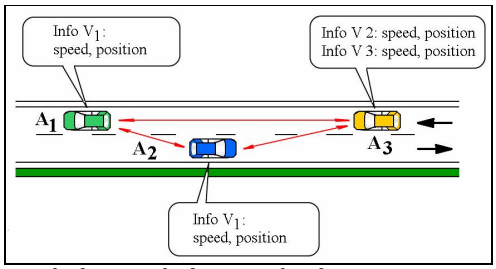


Figure 2. Vehicle-To-Vehicle inter vehicular communication system

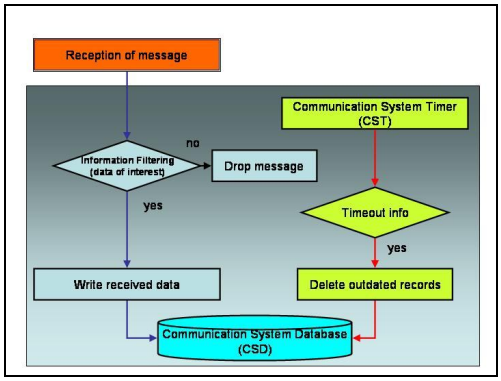


Figure 3.V2V exchange and analyzer data protocol

MATERIALS AND METHOD

Using the Global Positioning System we can determinate the in-time position of moving agricultural machines. The proposed algorithm for detection the possibility for two autonomous agricultural machines to collision, are based on the information acquired by GPS system and in-vehicle sensors system.

Using the notation form the route contention presentation in figure 4 can note that if tgα=tgβ the agricultural machines travel on a parallel path and they cannot meet at any time point and if (tgα) are not equal with (tgβ) then:

$$tg\alpha = \frac{y_{CP} - y_1^{'}}{x_{CP} - x_1^{'}} \Rightarrow y_{CP} - y_1^{'} = x_{CP} \cdot tg\alpha - x_1^{'} \cdot tg\alpha \quad (1)$$

$$tg\beta = \frac{y_{CP} - y_2^{'}}{x_{CP} - x_2^{'}} \Rightarrow y_{CP} - y_2^{'} = x_{CP} \cdot tg\beta - x_2^{'} \cdot tg\beta \quad (2)$$

The estimated coordinates of the collision point are:

$$x_{CP} = \frac{1}{tg\beta - tg\alpha}\left[x_2^{'} \cdot tg\beta - x_1^{'} \cdot tg\alpha + y_1^{'} + y_2^{'}\right] \quad (3)$$

$$y_{CP} = \frac{1}{tg\beta - tg\alpha}\left[tg\beta \cdot tg\alpha(x_2^{'} - x_1^{'}) + y_1^{'} \cdot tg\beta + y_2^{'} \cdot tg\alpha\right] \quad (4)$$

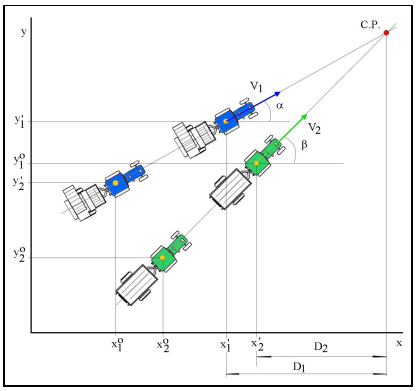


Figure 4. The mathematical model of anti collision algorithm

The vehicles (AAM) can meet at the collision point only if they reach it at approximately the same time.

The distances to the predicted collision point for the two autonomous agricultural machines considered are:

$$D_1 = \sqrt{\left(x_{CP} - x_2^{'}\right)^2 + \left(y_{CP} - y_2^{'}\right)^2} \qquad (5)$$

$$D_2 = \sqrt{\left(x_{CP} - x_1^{'}\right)^2 + \left(y_{CP} - y_1^{'}\right)^2} \qquad (6)$$

The estimated time moments (t_1) and (t_2) when agricultural machines are supposed to reach the collision point are:

$$t_1 = \frac{D_1}{V_1} \qquad (7)$$

$$t_2 = \frac{D_2}{V_2} \qquad (8)$$

The autonomous agricultural machines can collide when both of them arrive at the same moment to the collision point or when one arrives at the collision point and other is passing trough.

Therefore we introduce a time interval (CPTT- Collision Point Time Threshold).

For the condition:

$$\left|t_1 - t_2\right| \le CPTT \qquad (9)$$

, the vehicles are considered in danger to collision and the hardware equipment must do the necessary actions to avoid that (trough the implemented software commands).

CONCLUSIONS

- The first steps in the development and construction of autonomous agricultural machines is creation and a feasible implementation of algorithms that are needed to resolve the problems about moving, working, collision, in-field decision etc.;
- The main characteristic of algorithms is need to be the simplicity to can be implemented in low-cost (but reliable and fully functionally) hardware equipment;

- In the above desiderates the present paper propose an anti collision algorithm between two (or more) autonomous agricultural machines based on GPS systems and V2V (Vehicle-To-Vehicle) inter vehicular communication protocol.
- It is also the first national study by addressing and (future) implementing research results in agricultural autonomous machines development.
- Future research directions will be channelled towards the achievement of a functional prototype of an autonomous agricultural machine which is implemented algorithm anti collision, immediate practical application is directed towards automating the process of roots plant harvesting and transport.

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