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ASSESSMENT OF THE DEGREE OF TRAINING THE OPERATOR OF A MODERN SIGNALING AND CONTROL DEVICES

Summary

The article presents the problem of assessment of the degree of operator training for modern parallel driving system, used in a precision agriculture. The training was conducted for ten potential operators and their skills were rated subjectively after determined number of experimental runs. Data containing information about individual journeys were collected during the training. Then the trajectory errors based on charts illustrating their course were assessed. In conclusion the benefits resulting from analysis were formulated as well as the concept of further research.
Key words: *signaling and control devices, parallel driving system, ergonomics*

OCENA STOPNIA WYSZKOLENIA OPERATORA NOWOCZESNYCH URZĄDZEŃ SYGNALIZACYJNO-STEROWNICZYCH

Streszczenie

Artykuł prezentuje problem oceny stopnia wyszkolenia operatora nowoczesnej nawigacji na pasach równoległych, stosowanej w rolnictwie precyzyjnym. Przeprowadzono szkolenie dziesięciu potencjalnych operatorów oceniając subiektywnie ich umiejętności, po wykonaniu określonej liczby przejazdów eksperymentalnych. Podczas szkoleń zebrano dane zawierające informacje o poszczególnych przejazdach. Następnie dokonano oceny odchyleń od trajektorii na podstawie wykresów ilustrujących przebieg błędów. W podsumowaniu sformułowano korzyści płynące z przeprowadzonej analizy oraz koncepcję dalszych badań.
Słowa kluczowe*: urządzenia sygnalizacyjno-sterownicze, nawigacja na pasach równoległych, ergonomia*

1. Introduction

Precision engineering relies on two fundamental systems: GPS (Global Positioning System) and GIS (Geographic Information System). The earlier, GPS, is a system based on satellite navigation, and serves for precise definition of location of items on Earth [1, 2, 3]. One of the possible applications of GPS in precision agriculture involves monitoring of machinery operation using appropriate signaling and control devices cooperating with such machinery. Such area of agricultural activities includes, among others, driving tractors on parallel strips.

Systems that allow positioning the tractor or an agricultural machine on the field to support the operator's work by exact leading the tractor on the path, as well as automatic drive without the operator's participation, include not just the aforementioned GPS, but also LPS (Local Positioning System). This is a system that can also be used in places where the satellite signal does not reach for various reasons [4]. Most devices supporting tractor operation in the field are the integrated navigations on parallel strips. They allow for many advanced driving schemes. They have in-built receivers of GPS or LPS signals, and allow to read-out such data as position, driving direction, or the area where the procedure takes place. The views of current positions can be presented as 2D or 3D graphics. In the vast majority of such devices, the system can be extended by control assistant modules (allows to achieve a greater precision), or automatic pilot (tractor driving without the operator's participation).

The practical difficulty faced by tractor operators cooperating with navigation systems on parallel strips is the problem with maintaining strain line of driving without deviations greater than 20-30cm, particularly when driving on a field with uneven borders or located on a hill.

2. Purpose and scope of works

In order to check the level of difficulty in operation of signaling and control devices with the LPS system, training was held for ten potential operators of a vehicle cooperating with navigation on parallel strips by Trimble (model CFX 750). The training for potential operators of the machine was performed by an actual trainer who observed the results during several dozen test drives (the number of passes was arbitrary, according to the subjective assessment of the supervisor, namely the trainer).

On the basis of such observation, the trainer made the decision on stopping the training where the actual trajectory was maximally approximate to the assigned one.

The objective of the study was to gather data illustrating operator's progress in driving the vehicle according to the navigation, and the analysis of trajectory error calculated on the basis of the gathered data. Appropriate selection of the trajectory error representation method and the analysis of such error have allowed to assess the degree of operator training.

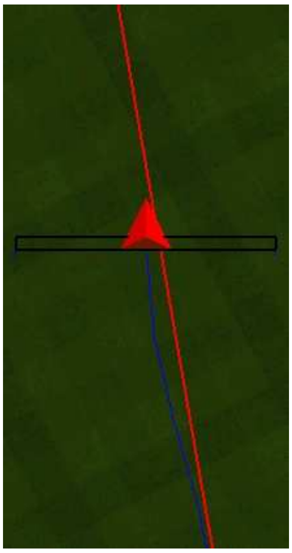
The scope of studies included:

- Training for ten potential operators of a vehicle cooperating with the navigation on parallel strips, and gathering data about each pass of particular operators. Due to high costs of fuel and depreciation of an agricultural tractor, experimental studies involved a regular car.

- The subjective assessment of the supervisor (decision about sufficient training of the operator) issued on the basis of observation of the operator's work.
- Transformation of the form of data gathered (photos into numerical data).
- Presentation of the trajectory error in a diagram.

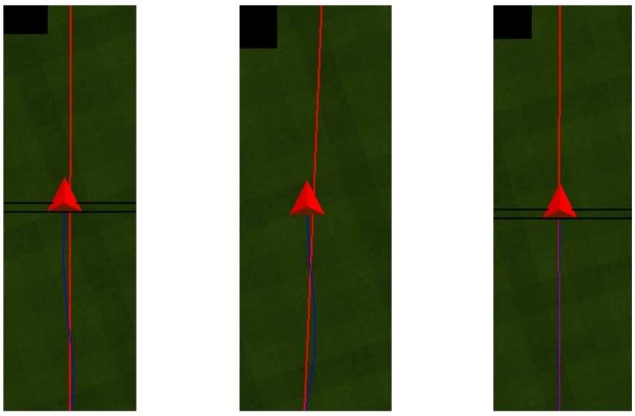
3. Methodology

The data about particular passes have been gathered by collecting navigation print screens with overlapping routes: assigned one (marked in red) and actual route (in blue) (Fig. 1 and 2).



Source: own work / Źródło: opracowanie własne

Fig. 1. Navigation print screen
Rys. 1. Zrzut ekranu nawigacji



1st pass 16th pass 44th pass

Source: own work / Źródło: opracowanie własne

Fig. 2. Phases of training of an exemplary operator (results from 1st, 16th and 44th pass)
Rys. 2. Etapy szkolenia przykładowego operatora (wyniki z przejazdu 1., 16. i 44.)

The training involved the number of passes indicated by the trainer. It was stopped where the operator, on trainer's request, performed 5 correct passes. The pass was deemed incorrect where the navigation signaled too large deviation of the route with red control diodes.

A specially developed application served to transform pixels (forming the routes: red and blue) of the collected images into numerical form. The obtained numbers represent position of vectors x_{rz}, y_{rz}, x_z, y_z, where:
x_{rz} – vector x of actual route,
y_{rz} – vector y of actual route,
x_z – vector x of assigned route,
y_z - vector y of assigned route.

Because vectors x are the same, and the actual and assigned routes differ exclusively with the position of vector y, such vectors were set together, and absolute value was calculated from the difference between vector y of actual and assigned routes.

Table 1 presents an example of a fragment of calculations of the trajectory error for any pass of an operator.

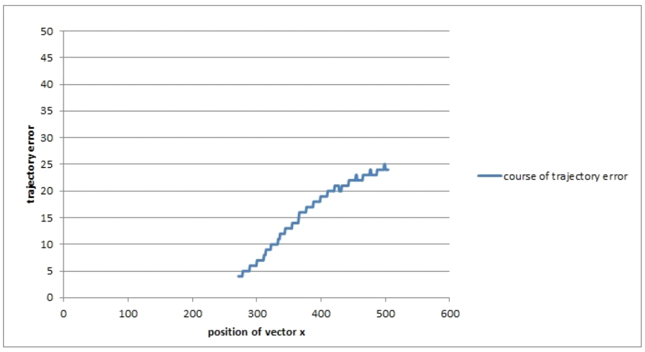
Table 1. Trajectory error calculation
Tab. 1. Obliczenie błędu trajektorii

Operator No. 9, pass No. 1				
assigned trajectory (red line)		**actual trajectory (blue line)**		**trajectory error**
wektor x_z	**wektor y_z**	**wektor x_{rz}**	**wektor y_{rz}**	**(y_z-y_{rz})**
246	432	246	399	33
247	432	247	399	33
248	431	248	399	32
249	431	249	399	32
250	431	250	399	32
251	431	251	399	32
252	431	252	399	32
253	431	253	399	32
254	431	254	399	32
255	431	255	399	32
256	431	256	399	32
257	431	257	399	32
258	431	258	399	32
259	431	259	399	32
260	431	260	399	32
…	…	…	…	…
479	414	479	383	31

Source: own work / Źródło: opracowanie własne

In order to present the volume and course of the trajectory error, the diagram presents the interdependence between vector x and absolute value of the difference between vectors y_z and y_{rz}.

The exemplary diagrams of trajectory errors in selected passes of an operator are presented below (Fig. 3-7).



Source: own work / Źródło: opracowanie własne

Fig. 3. The course of trajectory error in the 1st pass
Rys. 3. Przebieg błędu trajektorii w 1. przejeździe

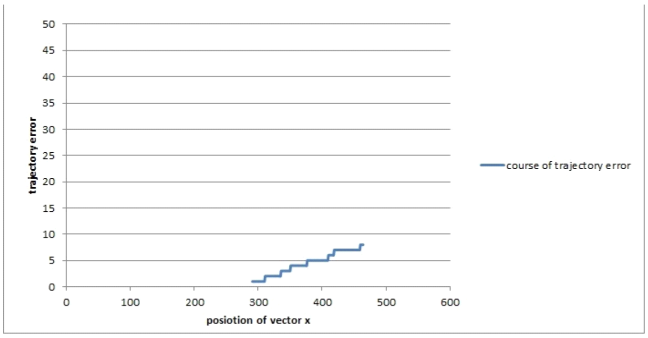


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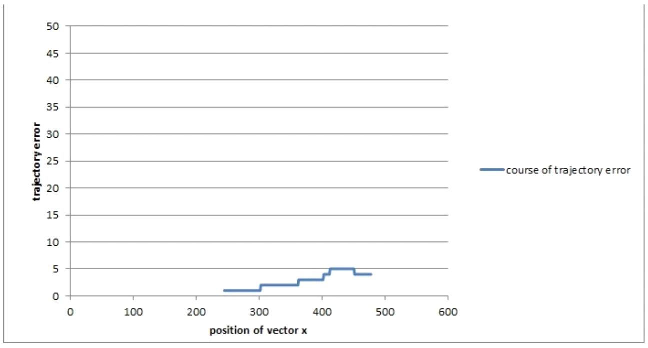
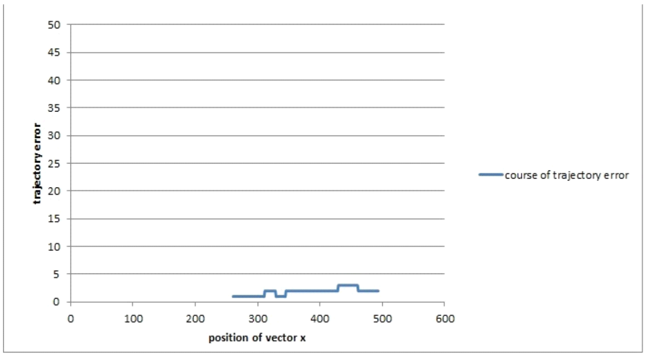
Fig. 4. The course of trajectory error in the 7th pass
Rys. 4. Przebieg błędu trajektorii w 7. przejeździe



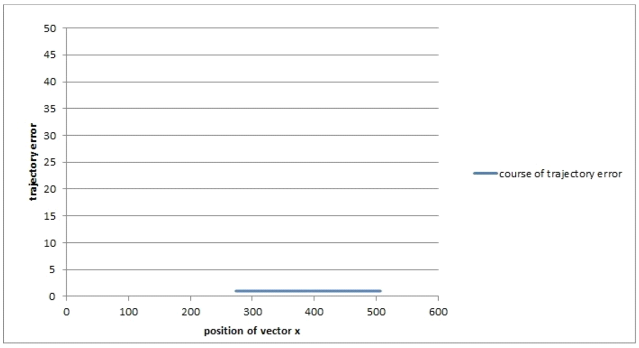
Source: own work / Źródło: opracowanie własne

Fig. 5. The course of trajectory error in the 13th pass
Rys. 5. Przebieg błędu trajektorii w 13. przejeździe



Source: own work / Źródło: opracowanie własne

Fig. 6. The course of trajectory error in the 19th pass
Rys. 6. Przebieg błędu trajektorii w 19. przejeździe



Source: own work / Źródło: opracowanie własne

Fig. 7. The course of trajectory error in the 25th pass
Rys. 7. Przebieg błędu trajektorii w 25. przejeździe

4. Results of the analysis

The position of vectors x and y was defined by the position of single points forming the red and blue lines. It can be thus assumed that the unit defining the trajectory error in the photograph should be points. The criteria adopted by the trainer supervising actual progress of the operators allowed him to stop the training when the operator drove along the route correctly three times. This means that each pass should be signaled by navigation with green diodes.

In diagram analysis this means that the trajectory error should not exceed three points.

The analysis involved diagrams of trajectory error for all passes of each of the ten operators. The analysis of such errors pointed out that most operators mastered driving according to navigation already after 20-25 passes. In three cases the training should be stopped after about 15-17 passes, while in one case – after the 8th pass. The number of passes per operator during the training remained within the range of 25-75, on average being 50 passes per person. This means that in all cases the training lasted too long and the number of route sections covered by the operators was too high.

5. Summary and conclusions

A tool allowing monitoring operator's progress during the training would enable time savings and reduction of (1) costs related to fuel, and (2) vehicle wear.

The analysis of single diagrams brought good results, but this is a method requiring too much time and effort. Therefore, appropriate IT tools should be selected to enable obtaining a clear objective decision about the degree of operator's training.

The calculated trajectory errors transformed to the polynomial with a predefined degree could serve as input data for the neuron network taught on the basis of the data gathered during the observation of the training process involving actual operators while using (as a template in the learning process) the grades awarded by the training supervisor.

The research problem presented in the summary shall be followed in further studies by the authors.

6. References

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