Vision based crop plant identification for weeding operations

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The context is the research project SAAPIN (Autonomous System for Precision and Integrated Agriculture), whose aim is to develop an autonomous system able to navigate through maize fields and to perform mechanical weeding operations. The scope of the presented work is to propose a novel algorithm to identify maize plants for optimizing weeding operations during the first weeks. This algorithm is based on the stem identification of the crop plants in coexistence with weeds. The discrimination system to identify the maize crop stalks is an intelligent vision-based system. The emphasis of the weeding operation is intra-row, where the competition is more important due to the proximity between crop plants and weeds.

The autonomous system is comprised by a tractor platform, which is going to navigate autonomously and by the mechanical weeding implement, to perform the weeding operations. A small tractor was selected and adapted to perform autonomous navigation by integrating sensors and by performing mechanical adaptations. Due to the need of performing intra-row-weeding the tractor navigates directly over the crop row. The weeding operation will be done by vertical axis rotary brushes. The concept of the weeding system is presented with two main tasks: to discriminate between crop and weed, and to act on the weeds. The discrimination task will be performed by a vision perception system, where the maize plants are identified and security areas without weeding are defined around them. The discrimination system proposed is placed covering the scene providing artificial light to have controlled light conditions. A color camera is used and the resolution and height was determined by taking into account the problem features.

The proposed algorithm is comprised of several phases: first an image is taken, afterwards the vegetation (crop and weed) is segmented based on chromatic indexation. Afterwards morphological operations are applied to modify the shape of the image objects to compensate crop defects and to minimize the existent overlaps between crop and weeds as well as the weed itself. Once very small weeds are discarded, morphological descriptors of each image component are extracted to identify its shape and to discriminate morphologically maize plants in the different growth states. Several classifiers were analyzed to determine which one requires the minimum number of parameters, and which was the most efficient in terms of implementation and classification. The classifier finally chosen was Ripper. Once the classification takes place, the maize stems have to be identified. The maize crop detection is based on a set of geometric rules and morphological operations whose aim is to determine the lines which fit better with leafs which allow to determine the stem position. The stem search is based on the maize crop structure by taking into account that the stem is closed to one of the leaf extremes. Trajectories and safe areas for the rotary brushes are generated based on the position of the stems.

References

Åstrand B., Baerveldt A. J., A vision based row-following system for agricultural field machinery, Mechatronics, Volume 15, Issue 2, March 2005, Pages 251-269

Southall B., Hague T., Marchant J.A., Buxton B.F., An autonomous crop treatment robot. A Kalman filter model for localization and crop/weed classification. The international journal of robotics research, 2002 Vol.21, No1, pp. 61-74.

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CONTEXT

The work done was performed within the research project SAAPIN (Autonomous System for Precision and Integrated Agriculture), whose aim is to develop an agricultural autonomous system able to navigate through maize fields and to perform mechanical weeding operations.

SCOPE

The goal of the work is:

- to propose a novel algorithm to identify maize plants for optimizing weeding operations during the first weeks. This algorithm is based on the stem identification of the crop plants in coexistence with weeds.

METHODOLOGY

- The autonomous system is comprised by a tractor platform, to navigate autonomously and by the mechanical weeding implement, to perform the weeding operations
- Due to the need of performing intra-row-weeding the tractor navigates directly over the crop row. The weeding operation will be done by vertical axis rotary brushes
- Proposed algorithm is comprised of several phases

Autonomous system

Weed-infested maize field

RESULTS

Algorithm

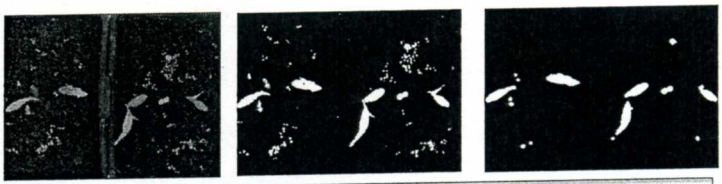
- Algorithm for the steam identification is comprised of several phases:
  - Vegetation segmentation, chromatic indexation
  - Morphological operations. Fill, opening
  - Components identification and descriptor elements
  - Components classification into weed, maize (leaf, plant) groups
  - Stem position estimation based on Hought Transform and geometrical rules

Classification

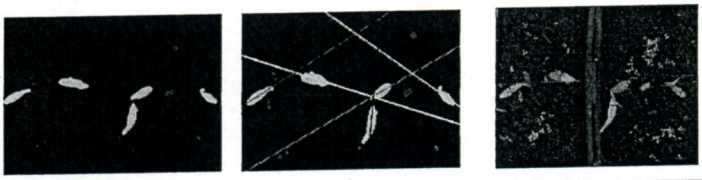
Classifier	% Success	% Error	NoR
Multilayer Perceptron	88,7019	11,2981	NA
SVM	88,4615	11,5385	NA
NaiClass	88,7	11,3	45
RIPPER	88,4615	11,5385	5
C4.5	87,9808	12,0192	19
Random Forest	87,2596	12,7404	NA
Bayes	84,8558	15,1442	NA
EFUNN	79,8077	20,1923	37

where NoR is number of rules

Phases of the Trajectories generations for weeding



Maize **Segmentation** **Morphological operations**



Classification **Stem Estimation** **Trajectories generated**

MAIN CONCLUSIONS

- **Methodology for weeding: no detection of weeds but avoidance of maize plants**
- **Composed morphological parameters as descriptor elements for maize plants**
- **An algorithm for maize crops stem identification has been proposed**
- **Several classifiers were validated within the problem scope**

REFERENCES

Åstrand B., Baerveldt A. J., A vision based row-following system for agricultural field machinery, Mechatronics, Volume 15, Issue 2, March 2005, Pages 251-269
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