Computers and Electronics in Agriculture 110 (2015) 9–16

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Neural identification of selected apple pests

P. Boniecki [a], K. Koszela [a,*], H. Piekarska-Boniecka [b], J. Weres [a], M. Zaborowicz [a], S. Kujawa [a], A. Majewski [c], B. Raba [a]

[a] Poznan University of Life Sciences, Institute of Biosystems Engineering, Wojska Polskiego 50, 60-625 Poznan, Poland
[b] Poznan University of Life Sciences, Department of Entomology and Environmental Protection, Dabrowskiego 159, 60-594 Poznan, Poland
[c] Poznan University of Medical Sciences, Department of Computer Science and Statistics, Dabrowskiego 79, 60-529 Poznan, Poland

ARTICLE INFO

Article history:
Received 8 April 2013
Received in revised form 7 July 2014
Accepted 21 September 2014

Keywords:
Artificial neural network
Digital image analysis
Identification of apple pests

ABSTRACT

The subject of this study was to investigate the possibility of using artificial neural networks as a tool for classification, designed to identify apple orchard pests. The paper presents a classification neural model using optimized learning sets acquired on the basis of the information encoded in the form of digital images of selected pests. This study predominantly deals with the problem of the identification of 6 selected apple pests which are most commonly found in Polish orchards. Neural modeling techniques, including digital image analysis, were used to classify the pests.

The qualitative analysis of neural models produced, indicates that multi-layered perceptron (MLP) neural network topology achieve the best classification ability. Representative features, allowing for effective pest identification are 23 visual parameters in the form of 7 selected coefficients of shape and 16 color characteristic of pests. The dominant input variables of a neural model, determining the correct identification of the features, contain information about the color of pests.

Our results support the hypothesis that artificial neural networks are an effective tool that supports the process of identification of pests in apple orchards. The resulting neural classifier has been created to assist in the decision-making processes that take place during the production of apples, in the context of protection against pests.

1. Introduction

In the world of fruit, apples take the 4th place, after bananas, grapes and oranges apples (Kierczyńska, 2005). In 2004, apple harvests accounted for 12% of more than 500 million tons of fruit. Apples are one of the main horticultural products produced in Poland, where the production of apples, representing about 70% of harvested fruit (more than 80% of fruit from trees) is responsible for approximately 242 thousand specialized companies. Many of these farms produce only apples (Kierczyńska, 2005; Piekarska-Boniecka et al., 2008a,b). It is worth noting that Poland is one of the world leaders in the manufacture and export of apple concentrate. One of the important issues associated with the production of apples is the problem of effective protection of plantations against pests.

Maintaining effective observation for the identification of pests (qualitative and quantitative) and the level of pest risk caused by individual species, are among the most important elements of the rational protection of plants. Pests can vary in number during the season as well as during the whole year (Kubiak et al., 2000). The damage potential of insects on crops is mainly due to their feeding. This results in far-reaching changes in the morphology and physiology of plants, which in turn leads to their destruction and decay.

Current methods of pest identification are based primarily on their visual identification by a human. The identification of pests is based on their pre-defined taxonomic character, such as color, shape and their bionomy or method of feeding. This requires considerable expertise, a good knowledge of the various groups and a lot of time. Insect classification methods are based on their determination – the specification of the name of the species using keys. The key to such a determination can generally be found in the form of a scientific publication or a monograph. It allows the identification of the insect as belonging to a given species through the comparison of black-and-white or color drawings and photographs. Depending on the type or species, the pest can be described by hundreds and even thousands of keys. This fact implies considerable difficulties in their determination.

* Corresponding author. Tel.: +48 502288097; fax: +48 61 848 7156.
E-mail address: koszela@up.poznan.pl (K. Koszela).

http://dx.doi.org/10.1016/j.compag.2014.09.013
0168-1699/

In order to recognize an object, a human uses his sight which forms a kind of a detector, producing signals which are then processed by the brain. During the introspection, an analysis is made in the brain of the form observed and subsequently an optimal decision-making process is generated which is responsible for the correct identification of the perceived object. The observed development of the broadly defined applied information technology allows the complex biological process of identification to be successfully simulated using modern digital equipment (Wena and Guyer, 2012; Pydipati et al., 2006; Singha et al., 2011; Banerjeea et al., 2008). For this purpose, rapidly developing information technologies, including modern methods of artificial intelligence, are used (Boniecki et al., 2009; Blackard and Dean, 1999; Diamantopoulou, 2005). This allows, as a result, the automation of the identification process and thus, it eliminates some of the problems arising from human nature, such as the subjectivity of assessment, fatigue, and other factors that generate errors in the observations made by a human (Nadimi et al., 2012; Sanzogni and Kerr, 2001; Smitha et al., 2009.).

One of the goals of current research in the field of artificial intelligence is the achievement of a situation in which a computer can perform information processing in a similar way as a human (Szczypinski and Zapotoczny, 2012; Ruiz et al., 2011). Image analysis using neural modeling is a relatively new branch of information technology, while its interdisciplinary character is closely linked with research on the methods of artificial intelligence (Yin and Ding, 2009; Slosarz et al., 2011; Grzesiak et al., 2006). It is used more and more in practical applications, such as in IT support processes dealing with the recognition of objects presented in a visual form (Velioglu et al., 2011; Boniecki et al., 2011; Nowakowski et al., 2009; Yadav and Jindal, 2001.). In this context, methods and techniques for extracting information encoded in the form of visual have great importance, usually carried out on the basis of pre-defined representative features. In the course of identifying, and then extracting the knowledge contained in visual empirical data which has the form of digital images, an important role is played by artificial neural networks which are taught under supervision, in other words, generated by 'method with the teacher (Boniecki, 2008; Kominakis et al., 2002).

Neural models are essentially a simplified simulation of the brain (Karaman et al., 2012). They have the ability to learn and are able to generalize knowledge acquired. At the same time, they are not very sensitive to incomplete and unclear input information. It is worth noting that trained neural networks process new input signals, giving the output results in real time (Movagharnejad and Nikzad, 2007; Boniecki et al., 2012a; Jayas et al., 2000; Koszela et al., 2013). Due to their characteristics, neural models are continuously increasing their practical applications (Yalcin et al., 2011; Jeyamkondan et al., 2001; Cabrera and Prieto, 2010; Bouharati et al., 2008; Bos et al., 1992).

The research study was aimed at supporting decision-making processes that occur during the production of apples (Kavdir and Guyer, 2003). The paper seeks to present an efficient way of detecting and identifying 6 selected apple pests, commonly found in Polish orchards. The above process involves both identification of a given pest, based on their representative characteristics, and adoption of visual parameters characterizing the coloration and shape of the given pests. The following research hypothesis has been used: visual information encoded in the form of digital photographs of selected pests is sufficient for the effective identification of these pests. For this purpose, it was necessary to check whether neural model is an adequate tool for the correct and effective identification apple pests, carried out on the basis of empirical data obtained by the method of image analysis. The following questions have arisen:

1. Which of the representative characteristics are necessary for the correct identification of pests?
2. Which neural network topology is optimal in the identification of pests?
3. What is the impact of the reduction of the vector components on the effectiveness of the identification of pests?
4. What is the impact of image parameters (resolution) on the effectiveness of the identification of pests?

The aim of this study was to investigate the possibility of using artificial neural networks as a tool for classification, which is designed to identify apple orchard pests (Boissarda et al., 2008; Jayas et al., 2000; Torrecilla et al., 2007). The proposed neural classifier may be a convenient instrument, helping entomologists in the process of identifying pests. A utilitarian purpose was to support the techniques of plant protection through effective neural identification of 6 most common apple orchard pests, performed on the basis of graphically coded information in the form of photographs of selected pests. An important advantage of the created neural model is the repeatability of the identification process and objectivity of the assessment. The generated neural model is dedicated as a structural element (core) of the expert identification system supporting the process of apple orchard protection (Jakubek et al., 2009).

Therefore, a set of neural classification models was developed and produced. The stages of this objective include:

1. the analysis of the problem,
2. the acquisition of empirical data in the form of digital images of pests,
3. the choice and selection of appropriate characteristic features, enabling the identification of pests,
4. designing, manufacturing and testing of a computer system which supports the extraction and conversion of visual data to form learning sets,
5. the choice of topology and the generation of selected structures of artificial neural networks,
6. the selection of an optimal neural model,
7. the identification of insects.

2. Materials and methods

2.1. Materials

Apple trees can be attacked by many species of pests but only a few of them can be found in commercial orchards. The research material, was a group of 6 most common pests feeding in apple orchards, which pose the biggest threat to apples (Piekarska-Boniecka et al., 2008b).

These were:

1. Apple blossom weevil [*Anthonomus pomorum* (L.)] COLEOPTERA, CURCULIONIDAE Fig. 1.

It is a black-brown beetle, 4–6 mm in length, with a white patch in the shape of the letter 'v' on the elytra. It has a slender body and

Fig. 1. *Anthonomus pomorum* (L.).