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NEURAL IMAGE ANALYSIS IN PROCESS OF COMPOST QUALITY IDENTIFICATION

Summary

The paper presents the experiments of compost images analysis carried out with two types of digital cameras working in daylight and ultraviolet light. The data collected with two cameras were analysed with the usage of neural network model (using part of application Statistica v. 8.0). The results of images analysis were combined also with the results of chemical and physical analysis of composted material.

NEURONOWA ANALIZA OBRAZU W PROCESIE IDENTYFIKACJI JAKOŚCI KOMPOSTU

Streszczenie

W pracy zaproponowano oryginalną metodę oceny jakości kompostu, z wykorzystaniem nowoczesnych technik analizy obrazu, dokonaną w oparciu o zdjęcia pozyskane z dwóch typów aparatów cyfrowych, pracujących w świetle dziennym oraz świetle ultrafioletowym. Zebrane dane poddane zostały analizie za pomocą sztucznych sieci neuronowych z wykorzystaniem numerycznego symulatora SNN zaimplementowanego w postaci modułu w komercyjnym pakiecie Statistica v. 8.0. Otrzymane wyniki zostały następnie skojarzone z danymi uzyskanymi w oparciu o przeprowadzoną analizę chemiczną oraz fizyczną wybranych materiałów organicznych, poddanych procesowi kompostowania w warunkach laboratoryjnych.

1. Introduction

The sewage sludge, being rich in organic and inorganic plant nutrients, may substitute for a valuable fertilizer. The composting of sewage sludge with intense thermophilic phase can eliminate the risk of disease transmissions into the soil and agricultural products. The changes during composting process of sewage sludge mixed with carbonaceous amendments (wooden chips, sawdust, straw etc) let to obtain the fertilizer with much higher agronomic value than initially used "fresh" sewage sludge.

However, there are many difficulties to estimate the level of compost quality, especially stage of compost maturation. The physical and chemical analysis is long in time and must be proceed in laboratory. Thus, there is lack of fast and direct method of compost quality analysis.

Modeling by neural networks have seen an explosion of interest over the last few years, and are being successfully applied across an extraordinary range of problem domains, in areas as diverse as finance, medicine, engineering, geology, physics and picture analysis. Indeed, anywhere that there are problems of prediction, classification or control, neural networks are being introduced. This sweeping success can be attributed to a few key factors, mainly such as power and ease of use.

A lot of power in the calculation shows, that neural networks are very sophisticated modeling techniques, capable of modeling extremely complex functions. In particular, neural networks are non-linear (a term which is discussed in more detail later in this chapter). For many years linear modeling has been the commonly-used technique in most modeling domains, since linear models had well-known optimization strategies. Where the linear approximation was not valid (which was frequently the case) the models suffered accordingly. Neural networks models also keep in check the curse of dimensionality problem which bedevils attempts to model non-linear functions with large numbers of variables. Neural networks techniques are also intuitively appealing, based as they are on a crude low-level model of biological neural systems. In the future, the development of this neuro-biological modeling may lead to genuinely intelligent computers.

An important advantage of neural networks is a big ease its use. The neural models user gathers representative data, and then invokes training algorithms to automatically learn the structure of the data. Although the user does need to have some heuristic knowledge of how to select and prepare data, how to select an appropriate neural network, and how to interpret the results, the level of user knowledge needed to successfully apply neural networks is much lower than would be the case using (for example) more traditional statistical methods. Special roles as neural models as a tool to assist image analysis. Most used them to identify the information contained in graphic form.

The neuronal identification of pictorial data, with special emphasis on both qualitative analysis, is more frequently utilized to gain and deepen the empirical data knowledge. Extraction and then classification of selected picture features, enables one to create computer tools in order to identify these objects presented as, for example, digital pictures. In relationship from this, purposeful the search the modern helping in range of construction as well as exploitation of neuronal models educational process in context methods seems to be their utilization in picture analysis process.

2. Research material and scientific problem

The material on which the experiment is carried out comes from a special chamber compost, which preserves the conditions prevailing within the windrow. Adequate moisture and increased temperature (about 70-80 ° C) condition the correct operation of the process. They are samples that are a mixture of two types of organic material. Among four types of test material can be mixed:

- wheat straw and sewage sludge,

- rape straw and sewage sludge,
- dry maize straw and sewage sludge,
- maize straw and wet sewage sludge.

The method of determining the stage of the composting process is carried out by measuring the temperature inside the chamber, simulating conditions inside the windrow. Experienced person can determine on the basis of the external appearance of compost. On the basis of long-term observation according to the appearance of structure and color compost organic matter was decided to attempt to automate the method by optical analysis of samples. Scientific problem, solutions which have been taken in this work is complex and consists of several sub-problems. They can be framed in the form of the following questions:

- Do neural networks are an appropriate tool to identify the stage of the composting process on the basis of the information contained in the form of digital image?
- Does the bacteria in the organic matter will be fighting phosphorescence under the influence of UV light?
- Are any phosphorescence of bacteria will allow you to specify the degree of their development, which would make it easier to determine the maturity of compost?
- Is your digital camera is able to record the entire spectrum of light emitted by UV light?
- Is the use of mixed light (using white light emitting diodes and ultraviolet) will allow a more precise identification of maturity of compost?

3. Methodology

Empirical data in the form of photos of compost, derived are designed specifically to the bench. Inbox cubic made of OSB panels measuring 50 x 50 x 50cm in the middle is painted in black. This causes the absorption of light that falls on the wall, which eliminates any light reflections.

Fig. 1. Position of the measurements

In measuring the studio designed the opportunity to choose the type of lighting. Installed electroluminescence two types of light-emitting diodes (LED) that emit white light and UV. The place of their installation is a lid that can be mounted on four altitudes terms of sample: 11 cm, 23 cm and 34.5 cm, 39.5cm. Distances photography samples from the lens outer lens equate to 13 cm, 25 cm and 36.5 cm and 41.5 cm (not counting the ozone layer samples). Depending on your level of focus photography, correct exposure and white balance are adjusted manually. Other camera settings are as follows:

- sensitivity matrix: ISO¬ 80,
- veil: F2.8,
- time: 1 / 15 sec. (white light) and 1 / 4 sec. (UV light),
- focal length: 5.2 mm.

Photos are performed centrally (in advance), which causes a reduction in outlook and consequently makes it possible to get the best images imaging reality. Lighting is set linear respect the lens axis, which allows you to reduce shadows that formation in the light side. Location diodes have been designed to illuminate how best to frame. They use 30 LEDs that emit ultraviolet light, which positioned in the box 4 × 5, additional diodes in the vicinity of the hole to the camera. Similarly, white LED have been deployed. The arrangement of diodes presents the following fig. 2.

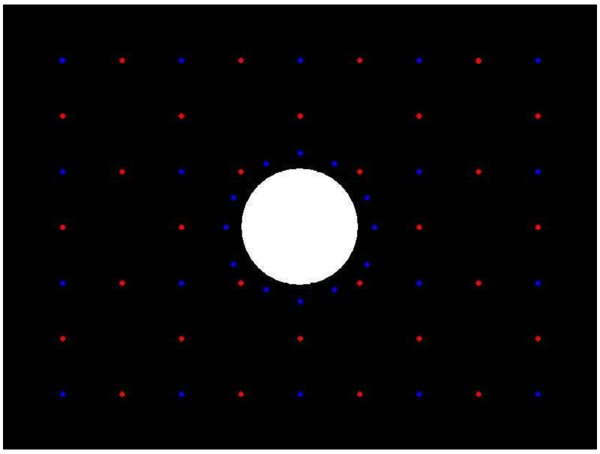

Fig. 2. Schematic layout diodes (blue-ultraviolet LED, red-white LEDs)

Two teams of LED are connected in parallel to the power source of power supply, which converts alternating current downloaded directly from the DC voltage of 3V. Inside a single team LED are connected in parallel. The flow rate at which obtained the optimal brightness LED, is about 20 mV. The application of power from the electricity network provides repetitive acquisition of lighting conditions. Ultimately, planned to take samples when you place the camera (or of the matrix) in the chamber composting. This will allow closer monitoring process by continuously measuring the temperature (currently) and to identify the appearance of the sample (the color and size fraction).

In order to produce teaching sets to generate neural models used the original application made for the purpose of the experiment conducted. Built system converting digital images to form acceptable by the *Statistica* v. 8 is commonly used in research on neural image analysis. Schema of artificial neural network model presents fig. 3.

4. Preliminary results

Presented below the pictures made in the studio are measuring the preliminary result of the apparatus built. Photos of the numbers 3 and 5 are images of samples taken in the light white. And photos of the numbers 4 and 6 are the equivalent of the samples using ultraviolet light-emitting diodes.

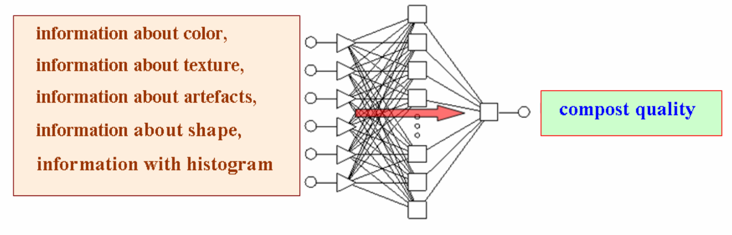

Fig. 3. Schema of artificial neural network model

Fig. 4. Photo samples of maize straw using white light

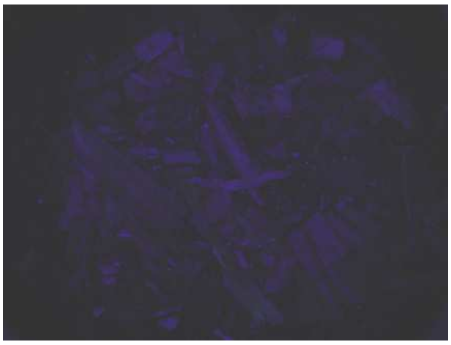

Fig. 5. Photo samples of maize straw using ultraviolet light-emitting diodes

Fig. 6. Photo samples of rape straw using white light

Fig. 7. Photo samples of rape straw using ultraviolet light-emitting diodes

5. Closing remarks

Made so far allowed the photos to draw the following conclusions regarding the proposed research methodology:

- Linear (with respect to the axis of the lens) lighting causing reflections of light that will disturb the process of image analysis. This effect is particularly visible in the ultraviolet light incident for smooth and wet surfaces. At the same time, the orientation of the same exposure (exposure time, diaphragms and ISO) for both types of lights, pictures made in the UV are clearly not illumination. Using these two seemingly adverse phenomenon, you can achieve interesting effects. Increasing exposure time to UV light (in relation to white light) can register only, and only the above-mentioned reflections. We believe that they will be useful in detecting edges and consequently determining the degree of decomposition of matter.
- Light reflections, albeit by a small margin, are also visible in white light. In order to minimize their plans to apply the filter polarization.
- Currently used the distribution of lighting does not provide uniform lighting in the frame. In this connected with planned to take additional diodes.
- When the camera small distances, and hence the lighting of the SAMPLE photograph compost dying light is too concentrated. It is therefore a photograph of a sample from a height of at least 25 centimeters (to a greater dispersion of light).
- Variables input into the proposed neural networks can be the following:

- properly encoded (ABGR or otherwise) averaged color from the total sample,
- minimum or maximum value of the brightness of the image samples or bottom quartile and the upper quartile histogram clarity (providing greater resistance to noise),
- number of objects that can be clearly distinguished from the background, after the above-mentioned edge detection (with pictures UV) radiation. When finished compost number of such artefacts should be significantly reduced.

6. Literature

[1] Kabarowski T.: Automated mammographic screening using artifical neural networks. Proc. 4th Conf. Neural Networks and their Applications. Zakopane 1999.

[2] Pinho A.j.: Modeling non-linear edge detectors using artifical neural networks. Proc. Annual Int. Conf. IEEE Engineering in Medicine and Biology Society, San Diego 1993, Vol. 15, pp.306-307.

[4] Boniecki P., Nowakowski K.: The classification of maize's kernels with supporting neuronal identification of shape,

Journal of Research and Applications in Agricultural Engineering, 2008, Vol. 53(3), p. 14-18 (in Polish).
[5] Boniecki P.: Elementy modelowania neuronowego w rolnictwie, WUP Poznań 2008 (in Polish).