Development of software for plant leaf area estimation

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Development of software for plant leaf area estimation

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Abstract. Created software capable of estimating leaf area in laboratory and field conditions. The software allows you to work with photos with any large-scale tags. The paper presents an example of using software with a real example.

1 Introduction

Computer technologies can be successfully used to perform a variety of measurement work in biological and agricultural research [1]. At the same time, a significant amount of time is often saved compared to the standard methodology, which involves working with traditional measuring instruments [2]. One of the promising methods of comparative morphology of plants used to assess the ecological state of the environment, is to determine the area of leaf plates [3]. It should be noted that we are talking not only about the study of contaminated sites, but also about laboratory experiments. It is known that under the influence of various physical factors, such as ionizing radiation [4], ultraviolet radiation [5], visible radiation [6], etc. Biochemical, physiological and morphological changes may occur in plants. With the high-intensity effect of physical factors, there is a development of oxidative stress [7], which is accompanied by damage to proteins [8], nucleic acids [9], etc. [10]. It should be noted that in some cases long post-effects may be formed, as, for example, it happens when long-lived active forms of proteins are formed [11], which are responsible for the secondary development of oxidative stress [12] and damage to macromolecules [13], including DNA [14]. Except for cases with growth suppression and damage to vital structures, this methodology can be applied when searching for optimal growth conditions of forage crops [15]. When conducting research related to the determination of the biological potential of plants, their comparative productivity in competitive strain testing, plant introductions and the agronomic effectiveness of the developed agrophytosystems. The scientific value of determining the area of leaf plates is associated with the determination of the photosynthetic potential and the net productivity of

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photosynthesis, which is the basis for assessing the productivity of a plant and the development of technological methods for growing it [16]. The currently used methods for determining leaf area are rather cumbersome and are related to the duration of this study. However, with a large amount of research requires speed and high accuracy of analysis. In this paper, a method is proposed for measuring the area of leaf plates of plants requiring a smartphone, which most people always have with them.

2 Methods

2.1 Software operation algorithm

Source RGB images of leaf plates of plant were obtained upright with the same distance from camera lens to leaf. To highlight the pixels corresponding to the image of the leaves, the following green highlighting procedure was applied:

\[ I_G = I_g - aI_r - bI_b, \]

where \( I_g, I_r, I_b \) - the intensities of the RGB color components of the pixel, \( I_G \) - result intensity of highlighted green, \( a, b \) - weights. Then threshold procedure was applied to determine leaf pixels. To estimate the area of sheets, the total number of pixels was normalized to the specific area of one pixel.

2.2 Agricultural tests

Previously, we obtained a photoconversion fluoropolymer film. Cd/ZnSe was used as a fluorophore, which was stabilized by gold nanoparticles with doped Eu ions. Composites of gold nanoparticles and Cd/ZnSr showed a higher quantum yield compared with gold nanoparticles doped with Eu ions. With the help of the technology developed by us, nanoparticles were incorporated into the photoconversion fluoropolymer. In this case, nanoparticles are combined into aggregates of the "chain" type. With the help of artificial light sources simulating sunlight, primary tests of fluoropolymer photoconversion films were carried out. It was shown that when illuminated with model sunlight through a photoconversion polymer films, a noticeable increase in the biomass accumulation is observed [17]. Moreover, in the early stages of development, there is a difference in the areas of the sheet plates. Photos taken in these experiments were used to test the program.

3 Results

Figure 1 presents a general view of the program. The program allows you to stream processing from the selected folder. You can also work with only one file.
Fig. 1. General view of the developed software.

When uploading an image to the software, you must ensure that the selected file and the selected scale are correct (Fig. 2). To do this, from the lower left corner of the software, labels are set for a known value. In this case, it is a growing pot with sides of 60 mm.

Fig. 2. View of the software window for file verification and scale setting

After choosing the scale of the photograph, the contours of the leaf plate begin to stand out automatically and determine the intensity of its color (Fig. 3).
Fig. 3. View of the software window for verifying the file of the selection of the sheet plate

After that, the area of the leaf plate and the intensity of the green channel on it are automatically calculated (Fig. 4). It is shown that the area of two sheet plates is 135.8 cm² (13584 mm²). The area of the left sheet is 109.4 cm² (10941 mm²), the area of the right sheet is 26.4 cm² (2643 mm²). In sum, the area of the right and left leaves corresponds to the total calculated area. As for the intensity of the green channel, it allows making assumptions of the concentration of pigments, which indirectly indicates the rate of photosynthesis. It should be noted that the intensity of the right and left leaves are different. For the right sheet it is about 81 a.u., for the right sheet it is about 75 a.u.

Fig. 4. View of the software window with the results.

4 Conclusions

In this paper, software has been created that allows automatic determination of leaf areas and the intensity of the green channel with the same initial illumination. It is shown that
plants grown under photoconversion fluoropolymer coating have a large surface of leaf plates. The new scientific results obtained as a result of our studies are in good agreement with the data of various scientific studies that have been obtained by other scientists [18-29].

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