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SPECIAL FEATURES OF GRAIN CROPS SPECTRAL ANALYSIS USING UAV

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Abstract. The monitoring of the agriculture fields vegetation state is a significant step in using of remote sensing for precision agriculture. No traditional airborne platforms like aircrafts and commercial satellites fit these uses because of their low resolution images. The problem can be solved by using UAVs.

In this article, UAV being equipped with visible spectrum camera was used to produce an image of the wheat field in tillering phase. Due to the high image resolution on photo image soil is also fixed as well as the plants. It will affect on the total spectral indicators of the planted area.

The aim of the study is to develop a methodology of distinguishing the wheat area from the soil area on photo images. Experiments were carried out within 40 – 100 m UAV's heights range for different states of soil – arable seedbed and dry dirt road. It has been established that it is important for f arable land being mostly fixed for sowings and, accordingly, the adjustment of filters should be carried out for each height monitoring apartly.

While selecting optical range filtration canal to distinguish plants from the soil while being analyzed by separated pixels of image it would be appropriate to use green and blue canals.

Key words: UAV, stress indices, nitrogen, harvesting routes, NDVI, remote monitoring, agricultural crops, spectral index.

Introduction

The emergence of UAVs in crop growing practices gave a powerful instrument for agrarians to monitor the fields condition adding available satellite solution because they had less dependence on weather conditions and had lower cost of high resolution images.

Formulation of problem

The use of UAV has its own characteristic according to conditions of management, thus in EU countries the size of the fields in dozens of hectares allows you to limit the fixation of the problem by fixation of problematic plots of land for future research, i.e. the equipment is working in the indicator mode. In Ukraine, average field area covers hundreds hectares. It requires the use of UAV's spectral equipment using the measuring mode because of limited time for making decisions about optimal quantity of fertilizers.

Acquisition of reproduced plants data while measuring spectral plants parameters is a difficult scientific and technical problem because it is necessary to take into account changes in lighting, the imaged soil in frame, etc.

Analysis of recent research results

The problem to take into account the changes in lighting was observed in many papers. For example, Mónica Herrero-Huerta et all (2014) [1] used artificial ground-based patterns, Jianfeng Zhou et all (2016) [2] applied an additional zenith sensor, Vitalii Lysenko et all (2017) [3] engaged a particular algorithm of survey for calibration.

The effect on the monitoring results from the available external field objects has not been properly studied. For example, in paper Jesper Rasmussen et all (2016) [4] it was shown the difference for the different heights data being received for object. The existence of such dependence has been experimentally proven in paper by Vitalii Lysenko et all (2016) [5]. Authors attributed this to the fixation of soil through the high resolution of the digital photo-camera. According to this, for row crops and sowings in their initial phases due to the high resolution of sensor equipment the imaged soil in the frame will effect on the received results That phenomenon should be taken into consideration while indices of stress are being created.

It should be noted that in Ukraine there are about 300 types and subtypes of soils, the spectral indicators amounts of which may significantly varied due to humidification and other factors. The decreasing of the influence of external field objects may be reached by using such filters which are realized in specific software Stantview to be elaborated for Stantrange's sensors but setup the filters is implemented in manual mode and it will depend on operator's experience and his level of skills [6]. The study of filter parameters setup to remove external objects from the frame became the aim of exploration.

Reviewing the image of the field being made vertically from the UAV platform it's possible to note that there will be either the plants themselves or the soil with possible remains of organic matters from the previous year fixed in frame. The distinguishing of soil may be implemented using specialized hardware tools as well as spectral plants indicators or soil in near infrared spectrum (NIR) or using devices to analyze the object image.

To distinguish upper and lower plant's leaves with the help of hardware is possible with the help of advanced equipment – laser Identification Radar (LiDAR), which fix not only spectral indicators but also the distance to object in the form 3D model to allow to distinguish plants from soil without faulties. In papers by Jan U.H. et all (2014) в [7] they describe successful experiment to monitor nitrogen amount for wheat in tillering phase with the help of the mono-spectral LiDar Leica ScanStation2 with green colored laser (532 nm).

The same results were received in paper by Shouyang Liu et all (2017) [8] where the measuring laser was mounted on the tractor. For agrarian practice LiDAR was used to display water stress of plants by Xi Zhu (2015) et all ([9]), however, as it was showed in paper [7], proper reproducibility of results was obtained while radio frequency correction of lighting was with the help of the reflective panels which usage on a industrial scale is not appropriate. In paper by D. Hoffmeister (2016) ([10]) it was represented the multi Spectral LiDAR which lightning calibration may be sometimes possible while using the ratio of different canals by analogy with satellite solutions, however, at the modern stage of development the element base and power supplies the size and mass of equipment are unacceptable for using on UAV's platforms up to 10 kg. The additional restriction of this advanced technology is a possibility of uneven terrain to affect on the results too. For satellites platforms most of spectral indicators use near infrared canal which is needed to create soil line to distinguishing a plant from soil at a distance of about few hundreds kilometers. In paper by Richardson, A.J. et all (1977) [11] there were defined specified spectral indicators for satellite platforms to minimize the soil influence like SAVI, TSAVI, MSAVI but these indicators are very sensitive to lighting changes and also to the errors because of the mixed soil matter. In practice, more common index is NDVI. For example, in paper by Carlos de Souza et all (2017) [12] to identify maize rows on photo images with the help of UAV, this index was used with the additional filtration of pixels which differed from the average value by a certain percentage. In case of presence in a field a lot of additional objects like plant residues, such way for soil filtration may have the significant faulties in measuring. Reviewing the spectral sensor equipment structure, there were studies to distinguish either soil and plants or the optical range itself. In paper by of J.Torres-Sánchez et all (2014) [13] while monitoring of wheat condition on its early stage of vegetation to distinguish plants from soil there were used a lot of different vegetation indices being based on the optical canals among which ExG and VEG were the best ones.. The ExG index was successfully used to identify the soil, harvest (sunflowers and corn) as well as weeds in paper by Maria Perez-Ortiz et all (2016) [14], however, the identification was based on boundary value, i.e being adapted only for 2 objects. In reality, in photoshoot of field there may be much more objects like lighted or shaded soil which color components intensity may be higher or lower comparing with the value of plant.

Application solutions according to the frame filtration of pixels that do not belong to plants are being based on Object Based Image Analysis (further OBIA).

OBIA is one of the research directions of analyzing images and is mainly designed to distinguish or to segment images on meaningful objects by rate of their characteristics. In that case it's linked with other conceptions of analyzing images like segmentation images to be described in paper by Ghamisi et all (2012) [15] or the definition of superpixels or classes of pixels. The research about cluster pixels to identify plants is described in paper by of J. Senthilnath et all (2017) [16] where the possibility of effective plants identifying with using optical range is showed but the complexity of it's content for real objects multi-cluster system was noted.

An alternative to cluster analysis it may be analysis by each pixel apartly being proposed in the paper by T. Blaschke (2010) [17] and being improved in the paper by M.P´erez-Ortiz, et all (2015) [18] where were not only spectral indicated of pixels to be shown but it's location too. This approach requires much less computing resources and time to implement the analysis accordingly, that is definitely important during fertilization of plants in some definite stages of vegetation. In the exploration by Junfeng Gao et all (2018) [19] they were connecting the pixel and object-oriented analysis to monitor weed, but the specific feature of the object was sowing crop itself and cluster analysis was used exactly to determine cut not for other kinds of crops.

Purpose of research

According to analysis of literary sources it's possible to make a conclusion that it is possible to distinguish a plant from soil with the help of UAV with the use of pixel analysis within RGB colored space.

Results of research

The researches were conducted in the long-term stationary experiment by the Department of Agrochemistry and the Products of Crop Growing (GPS coordinates 50 deg 4' 30.00" N, 30 deg 13' 21.00" E). The studies were conducted with winter wheat, the vegetation phase – tillering. To explore the effect of different fertilizer there were chosen 2 ways of exploring exampling winter wheat without adding (0) and with normalized doze of mineral fertilizer to be recommended for such soil (1). To identify optic parameters of plants there were chosen adequate planted areas of field with different amount of fertilizers. For filters defining parameters there were the areas with arable land and road in air-dry condition taken apartly. As far as there are a lot of methods being based on using artificial optical patterns as separate object we observed the car's roof as a sample with homogeneous color and location directly near the field (Fig. 1).

Fig. 1. The experimental department's photo with the designation of areas: where: 0 and 1 – parts with wheat sowing without and with the recommended doze of fertilizers accordingly; arable– arable seedbed; road – dirt road (air-dry condition); sample – artificial optical pattern.

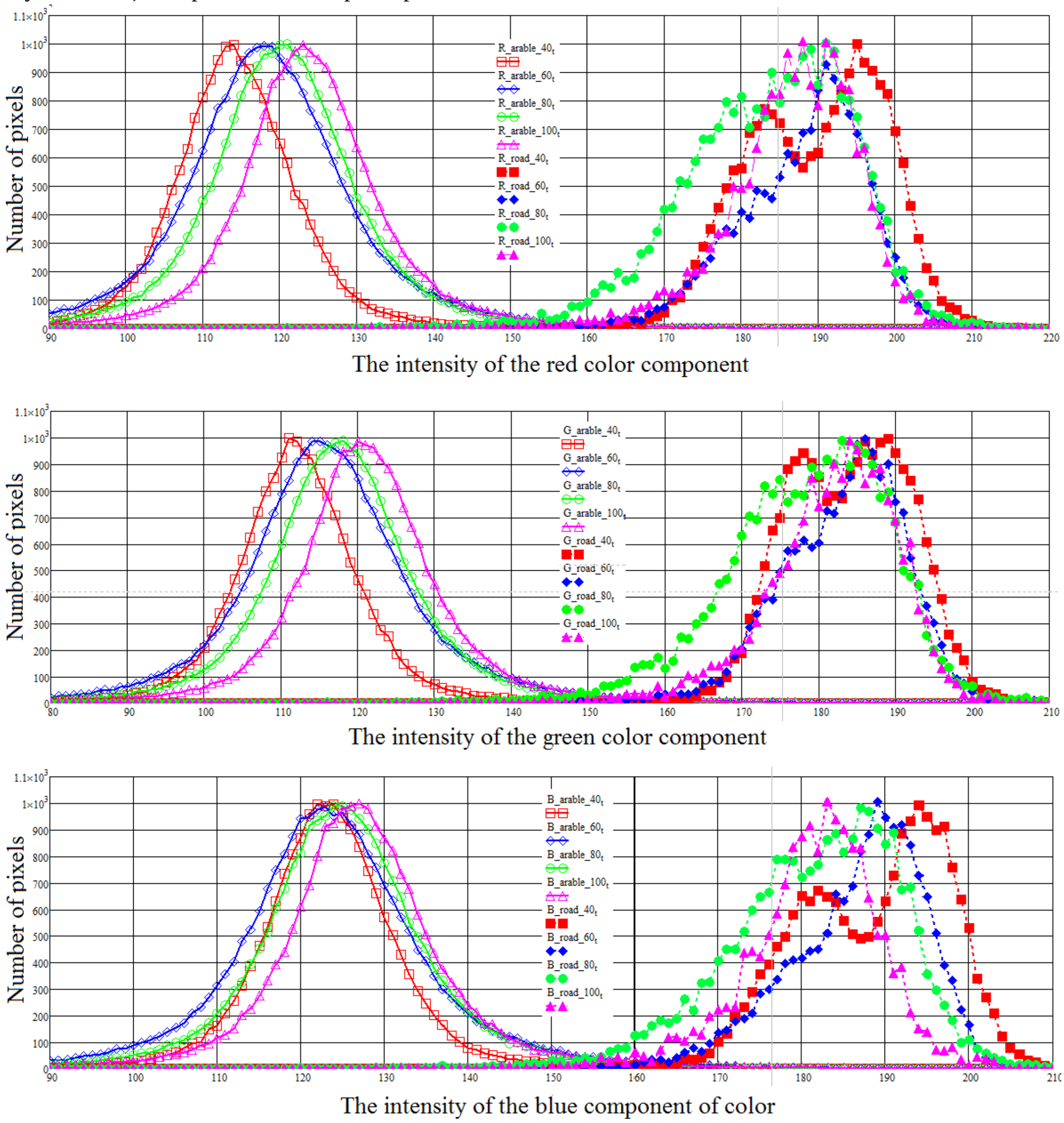

Fig. 2. The graph of dividing the number of pixels with the corresponding value of color components intensity for arable and soil road that are received from different altitude.

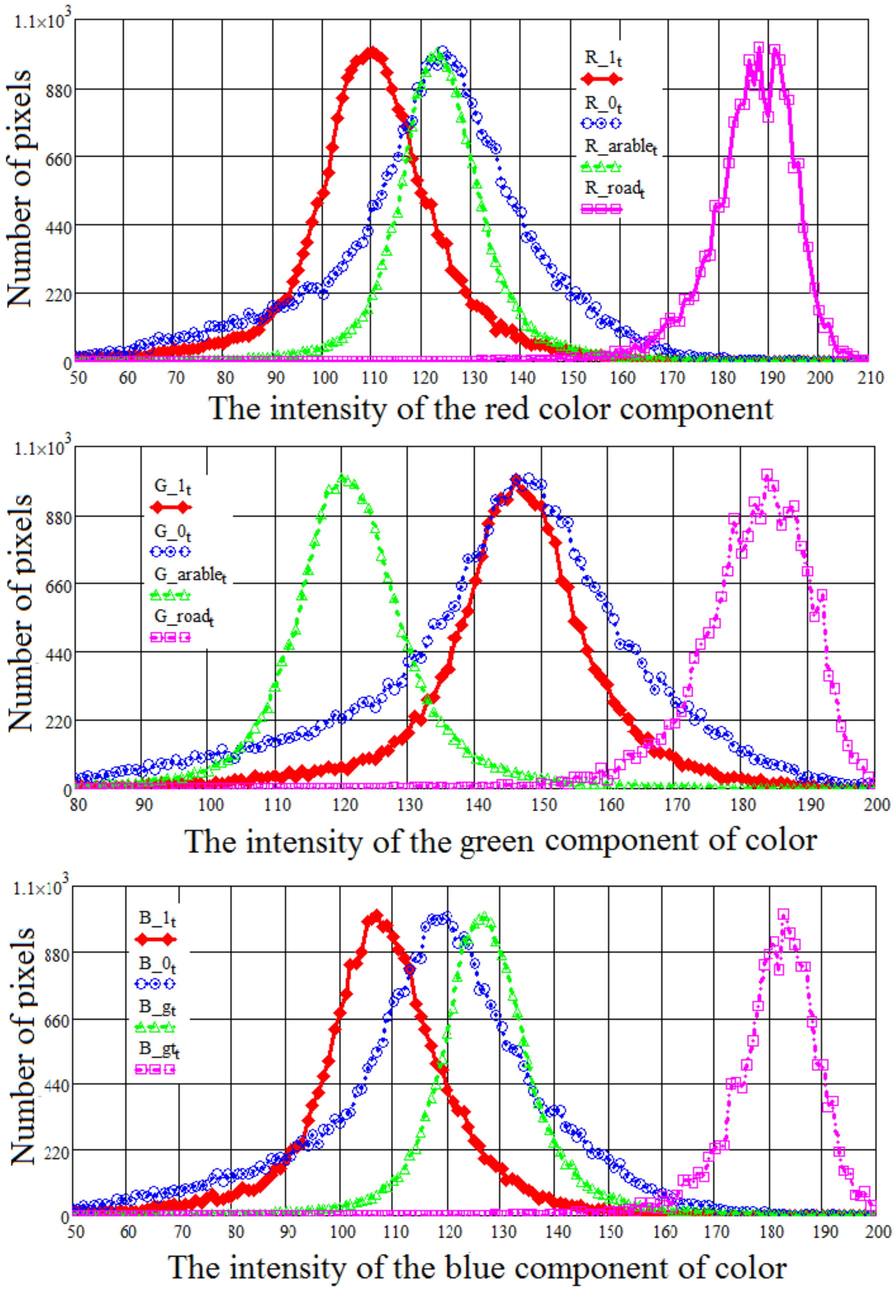

Fig. 3. Dividing the intensity of color components for soil and parts of wheat sowing.

UAV flight mode for adjusting of sensor equipment. The monitoring was implemented with the help of UAV DJI Phantom 3+. Camera Model - PHANTOM VISION FC200. Radio frequency calibration was made on a service-base data from exiiff file photoshoot in jpeg format about options of camera configuration basing the methods being described by I. Korobiichuk et all (2018) [20]. There were proposed adjusting parameters of digit camera during researches: Exposure Time – 1/701; Aperture Value – 2.8; Light Source - Fine Weather. Experiments were separately implemented at the altitude of 40, 60, 89 and 100 meters above the surface of field.

Software and applied algorithms. Mentioning that for monitoring there was format RGB sensor equipment used and all of the components of color were showed in single file, the MatchCAD (version 14.0.0.163) was chosen as program software being adapted for analyze colored images too. Output image where all imaged objects were previously divided into separate experimental parts with the help of abilities of the Microsoft Picture Manager (14.0.4750.1000) application and each part calculated within program MathCAD apartly.

While filters parameters determining the division of pixel numbers for each component of soil color was calculated. In the same way the parts of artificial pattern were processed. Mentioning that the number of pixels for parts of image depends on the altitude, the additional coefficient was introduced and the maximum number of pixels for any values of the intensity for the components of color was predicted in the range of 1000±30.

To determine average value of color components intensity for parts with wheat sowings it was calculated the average value for pixels being determined as ones which are not the soil components. To compare received results for the proposed methodic at the same time the computing with algorithm by I. Korobiichuk et all (2018) [20] was conducted for experimental parts with wheat sowings. According to such methods the average value of color components intensity was determined and after that the pixels which value were different from the average by 10 % were removed. Next step was recalculation average value.

The researches were conducted 12.04.2018 during the cloudless weather. During the researches with artificial pattern regardless of the height for all the components of color the results were in253-255 range, i.e results matched all the borders of 8-bit color model formation. It meant that further use of them was impossible.

Fig. 2 shows us the graphs of dividing the number of pixels with the appropriate value of color components intensity for arable seedbed and dirt road being received from different altitude. Represented data shows that each of spectral canal has it's own specific feature. The smallest dependence on altitude for arable seedbed to be fixed on images of sowing, was found for blue component (maximum in 122-127range), for red and green components – maximum in 114-124 range and 112-120 range. For the road with pressed soil the maximum difference in color components intensity value was founded the blue component.

The configuration of filters were made with the result of correlation the value of color components intensity for researched examples of wheat sowing and parts of soil (Fig. 3).

According to the filter configuration parameters of the existence objects in frame that are not plants, different ranges for values of color components intensity were chosen. Based on the assumption that for both parts of land assignment of value of color components intensity well described by a curve of Gauss, as the range for filtration, took values for which the number of pixels is greater than a certain percentage. For arable to configure the filter for 90% the ranges of filtration are R[120;126], G[117;124], B[123;130]. The results are showed on figure 4.

As the given data shows, for parts with normal dozen of fertilizer (1), starting with parameters of filter in 50%, red and blue canals of filtration gives almost the same results, for green canal the results are lower (<3%). For part without artificial fertilizer: green canal received less values. Computation according to method that are described in [20] for 0 and 1 parts were received the following values RGB [122; 145;118] and [109; 146;107]. Finally, parts with fertilizer were reproducible and for the results for the control part without fertilizers we had a significant difference, that was caused because of wet soil from arable land. Possible way of increasing the possibility of the results obtained in further research Is to take an account of parts that were identified as plants or soil. Also the perspective way is when filter by canal configures for definite range of values of color components intensity.

Conclusions

1. The thought of the expediency of filtering data by each pixel that are described in T.Blaschke [17] and M.P´erez-Ortiz [18], has been experimentally confirmed for monitoring with the use of UAV.

2. It's necessary to take into account the altitude when the filters are configured. For standard digital cameras of optical range (RGB color space), the smallest effect on flight altitude changes makes the blue channel.

3. The greatest reproducibility of the results under the different canals of filtration was obtained with red and blue canals, but they have low accuracy in wet soil and not a big sowings, due to that green canal could be more useful.

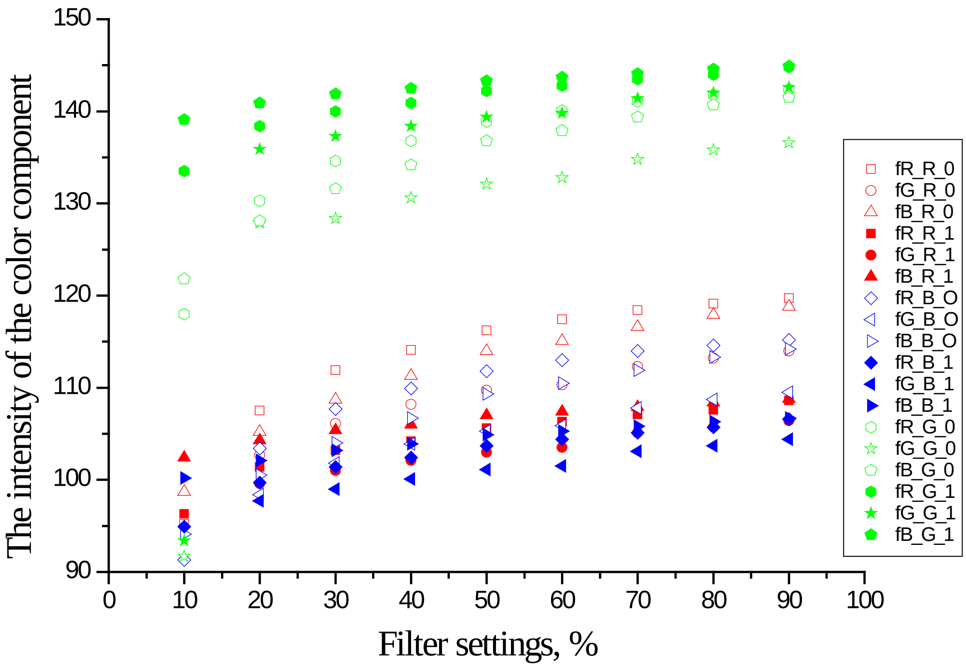

Fig. 4. Values of intensity of color components of wheat under the different values of configuration filter. Where: f(filtration canal)_(color components)_(plot).

References

1. *Mónica Herrero-Huerta, David Hernández-López, Pablo Rodriguez-Gonzalvez, Diego González-Aguilera, José González-Piqueras*. (2014). Vicarious radiometric calibration of a multispectral sensor from an aerial trike applied to precision agriculture. Computers and Electronics in Agriculture, Vol. 108. 28-38.

2. *Jianfeng Zhou, Lav R. Khot, Haitham Y. Bahlol, Rick Boydston, Phillip N. Miklas.* (2016). Evaluation of ground, proximal and aerial remote sensing technologies for crop stress monitoring IFAC-PapersOnLine. Vol. 49, № 16, 22-26.

3. *Vitalii Lysenko, Oleksiy Opryshko, Dmytro Komarchuk, Nadiia Pasichnyk, Nataliia Zaets, Alla Dudnyk*. (2017). Usage of Flying Robots for Monitoring Nitrogen in Wheat Crops The 9th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (21-23.09.2017), 30-34.

4. *Jesper Rasmussena, Georgios Ntakos, Jon Nielsen, Jesper Svensgaard, Robert N. Poulsen, Svend Christensen*. (2016). Are vegetation indices derived from consumer-grade cameras mounted on UAVs sufficiently reliable for assessing experimental plots? European Journal of Agronomy Vol.74, 75-92 http://dx.doi.org/10.1016/j.eja.2015.11.026.

5. *V. Lysenko, O. Opryshko, D. Komarchyk, N. Pasichnik.* (2016). Drones camera calibration for the leaf research. Scientific herald of the National University of Bioresources and Nature Management of Ukraine. Series: Engineering and Power Engineering of Agroindustrial Complex Vol. 252. 61-65. http://nbuv.gov.ua/UJRN/nvnau_tech_2016_25_10

6. *Gunchenko, Y. A., Shvorov, S. A., Rudnichenko, N. D., Boyko, V. D.* (2016). Methodical complex of accelerated training for operators of unmanned aerial vehicles. 2016 IEEE 4th International Conference Methods and Systems of Navigation and Motion Control, MSNMC 2016 – Proceedings. https://www.scopus.com/authid/detail.uri?authorId=57193057973.

7. *Jan U.H. Eitel, Troy S. Magneya, Lee A. Vierlinga, Tabitha T. Brownc, David R. Huggins*. (2014). LiDAR based biomass and crop nitrogen estimates for rapid, non-destructive assessment of wheat nitrogen status. Field Crops Research. 159. 21-32.

8. *Shouyang Liu, Fred Baret Mariem Abichou, Fred Boudon, Samuel Thomas, Kaiguang Zhao, Christian Fournier, Bruno Andrieu, Kamran Irfan, Matthieu Hemmerlé, Benoit de Solan*. (2017). Estimating wheat green area index from ground-based LiDAR measurement using a 3D canopy structure model Agricultural and Forest Meteorology. Vol. 247. 12-20.

9. *Xi Zhu, Tiejun Wang, Roshanak Darvishzadeh, Andrew K. Skidmore, K. Olaf Niemann.* (2015). 3D leaf water content mapping using terrestrial laser scanner backscatter intensity with radiometric correction. Journal of Photogrammetry and Remote Sensing 110, 14-23.

10. *Hoffmeister, D.* (2016). Chapter 11: Laser Scanning Approaches for Crop Monitoring. Comprehensive Analytical Chemistry, Volume 74, 343-361.

11. *Richardson, A. J.; Wiegand, C. L.* (1977). Distinguishing vegetation from soil background information. Photogrammetric Engineering and Remote Sensing Vol. 43. № 2. 1541-1552.

12. *Carlos de Souza, Rubens Lamparelli, Jansle Rocha, Paulo Magalhães*. (2017). Mapping skips in sugarcane fields using object-based analysis of unmanned aerial vehicle (UAV) images. Computers and Electronics in Agriculture. Vol. 143. 49-56.

13. *J. Torres-Sánchez, J.M. Peña, A.I. de Castro, F. López-Granados*. (2014). Multi-temporal mapping of the vegetation fraction in early-season wheat fields using images from UAV Computers and Electronics in Agriculture. Vol. 103. 104-113.

14. *María Pérez-Ortiz, José Manuel Peña, Pedro Antonio Gutiérrez, JorgeTorres-Sánchez, César Hervás-Martínez, Francisca López-Granados*. (2016). Selecting patterns and features for between- and within- crop-row weed mapping using UAV-imagery Expert Systems with Applications. Vol. 47. 85-94.

15. *Ghamisi, P., Couceiro, M. S., Benediktsson, J. A., Ferreira, N. M.* (2012). An efficient method for segmentation of images based on fractional calculus and natural selection. Expert Systems with Applications, 39, 12407-12417. URL: http://www.sciencedirect.com/science/article/pii/ S0957417412006756. doi:http://dx.doi.org/10.1016/j.eswa.2012.04.078.

16. *J. Senthilnath, Manasa Kandukuri, Akanksha Dokania, K.N. Ramesh*. (2017). Application of UAV imaging platform for vegetation analysis based on spectral-spatial methods. Computers and Electronics in Agriculture. Vol. 140. 8-24.

17. *Blaschke, T.* (2010). Object based image analysis for remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing, Vol. 65. 2-16.

18. *P´erez-Ortiz, M., Guti´errez, P. A., Pe˜na, J. M., Torres-S´anchez, J., Herv´as-Mart´ınez, C., & L´opez-Granados, F.* (2015). An experimental comparison for the identification of weeds in sunflower crops via unmanned aerial vehicles and object-based analysis. Advances in Computational Intelligence. Springer International Publishing Vol. 9094 of Lecture Notes in Computer Science. 252-262.

19. *Junfeng Gao, Wenzhi Liao, David Nuyttens, Peter Lootens, Jürgen Vangeyte, Aleksandra Pižurica, Yong He, Jan G. Pieters*. (2018). Fusion of pixel and object-based features for weed mapping using unmanned aerial vehicle imagery. International Journal of Applied Earth Observation and Geoinformation Vol. 67, 43-53.

20. *I. Korobiichuk, V. Lysenko, O. Opryshko, D. Komarchyk, N. Pasichnyk, A. Juś*. (2018). Crop Monitoring for Nitrogen Nutrition Level by Digital Camera, Automation 2018, AISC, volume 743. 595-603. (https://link.springer.com/chapter/10.1007/978-3-319-77179-3_56).

Список літератури

1. *Mónica Herrero-Huerta, David Hernández-López, Pablo Rodriguez-Gonzalvez, Diego González-Aguilera, José González-Piqueras*. Vicarious radiometric calibration of a multispectral sensor from an aerial trike

applied to precision agriculture. Computers and Electronics in Agriculture, 2014. Vol. 108. P. 28–38.

2. *Jianfeng Zhou, Lav R. Khot, Haitham Y. Bahlol, Rick Boydston, Phillip N. Miklas.* Evaluation of ground, proximal and aerial remote sensing technologies for crop stress monitoring IFAC-PapersOnLine. 2016. Vol. 49, № 16, P. 22–26.

3. *Vitalii Lysenko, Oleksiy Opryshko, Dmytro Komarchuk, Nadiia Pasichnyk, Nataliia Zaets, Alla Dudnyk*. Usage of Flying Robots for Monitoring Nitrogen in Wheat Crops The 9th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (21-23.09.2017), 2017. P. 30–34.

4. *Jesper Rasmussena, Georgios Ntakos, Jon Nielsen, Jesper Svensgaard, Robert N. Poulsen, Svend Christensen*. Are vegetation indices derived from consumer-grade cameras mounted on UAVs sufficiently reliable for assessing experimental plots? European Journal of Agronomy. Vol. 74, 2016. P. 75–92 http://dx.doi.org/10.1016/j.eja.2015.11.026.

5. *V. Lysenko, O. Opryshko, D. Komarchyk, N. Pasichnik.* Drones camera calibration for the leaf research. Scientific herald of the National University of Bioresources and Nature Management of Ukraine. Series: Engineering and Power Engineering of Agroindustrial Complex. Vol. 252. 2016. P. 61–65. http://nbuv.gov.ua/UJRN/nvnau_tech_2016_25_10

6. *Gunchenko, Y. A., Shvorov, S. A., Rudnichenko, N. D., Boyko, V. D.* Methodical complex of accelerated training for operators of unmanned aerial vehicles. 2016 IEEE 4th International Conference Methods and Systems of Navigation and Motion Control, MSNMC 2016 – Proceedings. 2016. https://www.scopus.com/authid/detail.uri? authorId=57193057973.

7. *Jan U.H. Eitel, Troy S. Magneya, Lee A. Vierlinga, Tabitha T. Brownc, David R. Huggins*. LiDAR based biomass and crop nitrogen estimates for rapid, non-destructive assessment of wheat nitrogen status. Field Crops Research. 2014. 159. P. 21–32.

8. *Shouyang Liu, Fred Baret Mariem Abichou, Fred Boudon, Samuel Thomas, Kaiguang Zhao, Christian Fournier, Bruno Andrieu, Kamran Irfan, Matthieu Hemmerlé, Benoit de Solan*. Estimating wheat green area index from ground-based LiDAR measurement using a 3D canopy structure model Agricultural and Forest Meteorology. 2017. Vol. 247. P. 12–20.

9. *Xi Zhu, Tiejun Wang, Roshanak Darvishzadeh, Andrew K. Skidmore, K. Olaf Niemann.* 3D leaf water content mapping using terrestrial laser scanner backscatter intensity with radiometric correction. Journal of Photogrammetry and Remote Sensing. 2015. 110, P. 14–23.

10. *Hoffmeister, D.* Chapter 11: Laser Scanning Approaches for Crop Monitoring. Comprehensive Analytical Chemistry, 2016. Volume 74, P. 343–361.

11. *Richardson, A. J.; Wiegand, C. L.* Distinguishing vegetation from soil background information. Photogrammetric Engineering and Remote Sensing. 1977. Vol. 43. № 2. P. 1541–1552.

12. *Carlos de Souza, Rubens Lamparelli, Jansle Rocha, Paulo Magalhães*. Mapping skips in sugarcane fields using object-based analysis of unmanned aerial vehicle (UAV) images. Computers and Electronics in Agriculture. 2017. Vol. 143. P. 49–56.

13. *J. Torres-Sánchez, J.M. Peña, A.I. de Castro, F. López-Granados*. Multi-temporal mapping of the vegetation fraction in early-season wheat fields using images from UAV Computers and Electronics in Agriculture. 2014. Vol. 103. P. 104–113.

14. *María Pérez-Ortiz, José Manuel Peña, Pedro Antonio Gutiérrez, JorgeTorres-Sánchez, César Hervás-Martínez, Francisca López-Granados.* Selecting patterns and features for between- and within- crop-row weed mapping using UAV-imagery Expert Systems with Applications. 2016. Vol. 47. P. 85–94.

15. *Ghamisi, P., Couceiro, M. S., Benediktsson, J. A., Ferreira, N. M.* An efficient method for segmentation of images based on fractional calculus and natural selection. Expert Systems with Applications, 2012. 39, P. 12407–12417. URL: http://www.sciencedirect.com/ science/article/pii/ S0957417412006756. doi:http://dx.doi.org/10.1016/j.eswa.2012.04.078.

16. *J. Senthilnath, Manasa Kandukuri, Akanksha Dokania, K.N. Ramesh*. Application of UAV imaging platform for vegetation analysis based on spectral-spatial methods. Computers and Electronics in Agriculture. 2017. Vol. 140. P. 8–24.

17. *Blaschke, T.* Object based image analysis for remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing, 2010. Vol. 65. P. 2–16.

18. *P´erez-Ortiz, M., Guti´errez, P. A., Pe˜na, J. M., Torres-S´anchez, J., Herv´as-Mart´ınez, C., & L´opez-Granados, F.* An experimental comparison for the identification of weeds in sunflower crops via unmanned aerial vehicles and object-based analysis. Advances in Computational Intelligence. Springer International Publishing. 2015. Vol. 9094 of Lecture Notes in Computer Science. P. 252–262.

19. *Junfeng Gao, Wenzhi Liao, David Nuyttens, Peter Lootens, Jürgen Vangeyte, Aleksandra Pižurica, Yong He, Jan G. Pieters*. Fusion of pixel and object-based features for weed mapping using unmanned aerial vehicle imagery. International Journal of Applied Earth Observation and Geoinformation. 2018. Vol. 67, P. 43–53.

20. *I. Korobiichuk, V. Lysenko, O. Opryshko, D. Komarchyk, N. Pasichnyk, A. Juś*. Crop Monitoring for Nitrogen Nutrition Level by Digital Camera, Automation 2018, AISC, 2018. volume 743. P. 595–603. (https://link.springer.com/chapter/10.1007/978-3-319-77179-3_56).

ОСОБЛИВОСТІ ЗЕРНОВИХ КУЛЬТУР СПЕКТРАЛЬНИЙ АНАЛІЗ З ВИКОРИСТАННЯМ БПЛА

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Анотація. Моніторинг сільськогосподарських полів стану рослинності є важливим кроком у використанні дистанційного зондування Землі для завдань точного землеробства. Немає традиційних бортових платформ, таких як літаки і комерційних супутників підходять ці використовуються з-за їх низької роздільної здатності. Проблема може бути вирішена за допомогою БПЛА.

У цій статті, БПЛА оснащуються камера видимого діапазону спектру була використана для того щоб зробити зображення поля пшениці у фазу кущення. Завдяки високій роздільній здатності зображення на фотографії грунту, а також а також рослин. Це вплине на загальне спектральних показників посівних площ.

Мета дослідження полягає в розробці методології розмежування площі пшениці з площі ґрунту на фотографії. Експерименти проводилися в 40 – висоти 100 м БПЛА діапазон для різних станів ґрунту – орної грунтом і сухій ґрунтовій дорозі. Було встановлено, що важливо для F ріллі, в основному, фіксовані для посівів і, відповідно, коригування фільтрів повинна проводитися для кожного моніторингу висота apartly.

При виборі оптичної фільтрації діапазону канал, щоб відрізняти рослини з грунту, аналізується відділений пікселі зображення доцільно використовувати зелений і синій канали.

Ключові слова: БПЛА, стрес-індекси, азот, маршрути прибирання, індекс NDVI, дистанційний контроль, сільськогосподарська культура, спектральний індекс.

ОСОБЕННОСТИ ЗЕРНОВЫХ КУЛЬТУР СПЕКТРАЛЬНЫЙ АНАЛИЗ С ИСПОЛЬЗОВАНИЕМ БПЛА

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Аннотация. Мониторинг сельскохозяйственных полей состояния растительности является важным шагом в использовании дистанционного зондирования Земли для задач точного земледелия. Нет традиционных бортовых платформ, таких как самолеты и коммерческих спутников подходят эти используются из-за их низкого разрешения. Проблема может быть решена с помощью БПЛА.

В этой статье, БПЛА оснащаются камера видимого диапазона спектра была использована для того чтобы произвести изображение поля пшеницы в фазу кущения. Благодаря высокому разрешению изображения на фотографии почвы, а также а также растений. Это повлияет на общее спектральных показателей посевных площадей.

Цель исследования заключается в разработке методологии разграничения площади пшеницы с площади почвы на фотографии. Эксперименты проводились в 40 – высоты 100 м БПЛА диапазон для различных состояний грунта – пахотной почвой и сухой грунтовой дороге. Было установлено, что важно для F пашни, в основном, фиксированные для посевов и, соответственно, корректировка фильтров должна проводиться для каждого мониторингу высота apartly. При выборе оптической фильтрации диапазона канал, чтобы отличать растения из почвы, анализируется отделен пиксели изображения целесообразно использовать зеленый и синий каналы.

Ключевые слова: БПЛА, стресс-индексы, азот, маршруты уборки, индекс NDVI, дистанционный контроль, сельскохозяйственная культура, спектральный индекс.