Application of UAV and Multispectral Camera for Field Survey in the Amur Region, Russia

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Abstract

UAVs create accurate cartographic data for early crop and soil analysis, which is useful when planning land works and crop care activities. During the season, there is a need to organize field monitoring, for example, the geography of the land to provide further land management and field survey to indicate a crop health condition. Currently, there is an acute question about the introduction of new technologies in agriculture. Moreover, there are problems in obtaining new knowledge of agronomists and farmers that it becomes impossible to promote such technologies in poorly developed regions. In this study, we want to show the use of a drone and a multispectral camera in assessing the health of crops for identifying areas with depressed vegetation. These technologies are bringing a useful step in the development of an agricultural management system in the direction of increasing the efficiency of land use. We have started to introduce smart agriculture in Amur Region, Russia, where soybean production is the main direction in the development of the region. This project aims to expand the application of new technologies in Amur Region and in the Far Eastern part of Russia.

1 Introduction

The use of multispectral camera and drone in agriculture are beginning to develop rapidly, and the issue of introducing these technologies into agriculture sphere is becoming urgent. Drones provide accurate map data for early analysis of the field, which is useful in the land management planning [1, 5]. Multispectral cameras are widely used by farmers around the world to monitor vegetation health changes with the use of visible and near infrared spectrum. Indicators obtained using the near-infrared spectrum, allow us to detect changes in vegetation long before the changes appear in the visible spectrum. In addition, multispectral cameras are widely used in such areas as biology, forestry, environmental studies, and control of infrastructure [2].

A crop survey of vegetation indices maps and high-resolution images are sources of actual information on the status of crops. According to these data, it is easy to detect areas with oppressed vegetation, disturbances of the seeding process, areas subject to erosion. Combined with agrochemical soil analysis, this data allows us to create prescription files for the differential application of mineral fertilizers [3]. In the absence of agrochemical survey data, the same maps of fertility zones are used to optimize sampling: instead of sampling on a regular grid, samples are taken by zones, which reduces the number of samples and reduces the effect of random factors on the analysis results. Sowing issues, such as bald field spots, crop damage after drought or flooding, and other factors, require operational monitoring, which only unmanned aerial photography can provide [4].

This direction is modern for Russia and until today unmanned aerial vehicles in agriculture have not been used. They are used in the Ministry of Emergency Situations, and others Ministries, but in recent years there has been a growing interest in agricultural UAVs.

Our aim is to introduce these technologies into agriculture through Amur Region and the Russian Far East. We cooperate in direction of agriculture development and strengthening the relationship between Russia and Japan. This study was made possible due to the joint research work between Niigata University and Institute of Soybean. This

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experiment showed the possibility in the allocation of the low greenery plot on the field by using technologies of smart agriculture.

2 The Study Site

The Amur Region is a federal territory of Russia, located in the upper and middle Amur River basin. Several features characterize the conditions for soil formation in Amur region:

- a cold winter with a little snow contributes deep soil freezing,
- the thawing of the soil and plant growth are slow due to a cold arid spring,
- a rainy and warm summer (half of the annual rainfall falls in July and August).

The weather conditions of the growing season of 2018 differed from the average long-term indicators for the southern zone of the Amur Region. The average monthly air temperatures in April and May were higher than the average values by 2.7 and 2.0 ° C, respectively (Fig. 1).

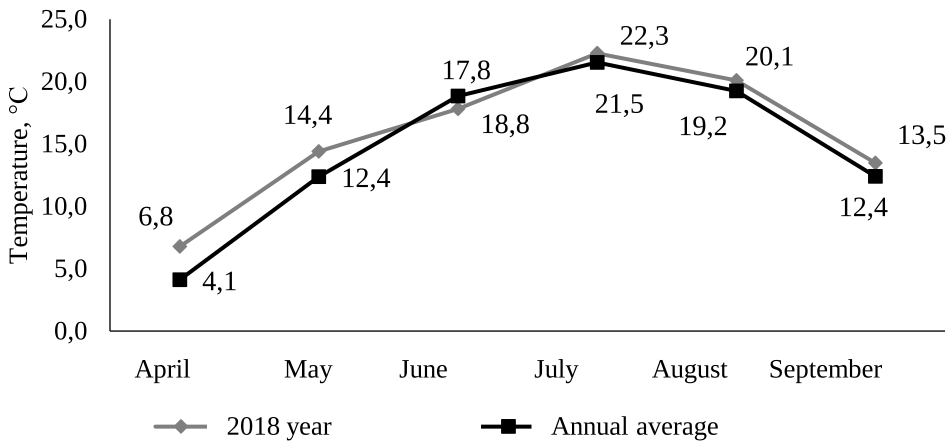

Figure 1: Average monthly air temperature during the growing season 2018

We made a map of the test site in cooperation with the Soybean Institute and Niigata University. Map of tests was allocated and visualised by software from images captured by UAV. As the study area the experimental field of Soybean Institute was chosen. The study site is a 1 ha soybean field located in Sadovoe village of Amur Region, Russia (Fig. 2). The study site coordinates are 50°10'8.70"N, 127°53'8.61"E (50.169055, 127.885637).

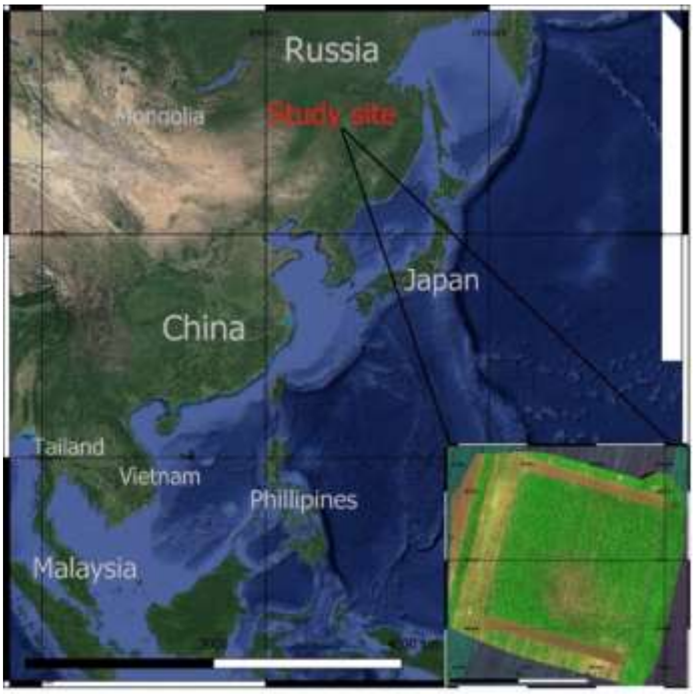

Figure 2: Study site

3 Materials and Methods

A test flight for agricultural remote sensing was established in 2018 by the Institute of soybean and Niigata University in the experimental site of Institute in Amur Region.

We used a UAV and a multispectral camera attached to it to take images. DJI's UAV Matrice 100 manufactured in China was used to capture images of the terrain. The camera focal size was 5.5 x 4.8 mm, and the GSD (Ground Sampling Distance) from the 80 m altitude flight was 5.45 cm/px. Front overlap and side overlap were set at 60% and 80%, respectively. The flight was carried out during solar noon, in the Amur Region this time at 12:30 pm. Pix4Dcapture software was used during image acquisition for the formation of the flight task and mission planning. Pix4DMapper was used to process raw data from the camera.

When processing images, matching points are searched between the images, which are subsequently merged. From this follows the requirement for images - they must have a total overlap area of over 65%. The software makes images computed for each pixel of the orthomosaic by the overlapping them into a full map [6]. Offset between the initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or non-calibrated images. Dark green ellipses indicate the absolute position uncertainty of the bundle block adjustment result (Fig. 3).

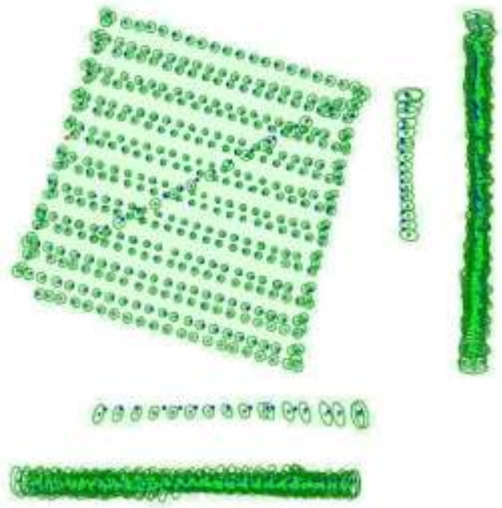

Figure 3: Computed Images, Ground control points

Computed image positions with links between matched images represented on the image as lines and ellipses. The darkness of the lines indicates the number of matched 2D keypoints between the images. Bright lines indicate weak links and require manual tie points or more images. Dark green ellipses indicate the relative camera position uncertainty of the bundle block adjustment result (Fig. 4).

Figure 4: 2D Keypoint Matches

4 Results and Discussions

An urgent task is to develop a technology for monitoring crops with the using of UAVs in the Amur Region, the model of which will be the basis of the decision-making system for efficient agro-industrial production. To assess the state of the territory, information is required, therefore, data collection, storage and processing are key elements in the monitoring process. For these purposes, photography from UAVs is the most optimal:

- an aerodrome is not required,
- the possibility of imagining with high spatial resolution and high photographic quality,
- accompanied by simple control.

The necessary step in remote sensing is to evaluate the health of plants - the lack of nutrients and the presence of viruses, pests, or weeds. By scanning the crop using both visible and near-infrared light, cameras on board a UAV can identify crops by colour. This information can create multi-spectral maps that track changes in plants and indicate their health. Besides, it is possible in the shortest time to identify the source of infection and take into account for further activities [1].

First, we made a map in RGB layer to visualize terrain, crops and objects on the fields (Fig. 5). The human eye recognizes images very well, so using the RGB image data makes the maps more understandable and readable. RGB images are suitable not only for imaging of a real surface (for example, satellite images or aerial photography), but also for displaying general information. This image showed the experimental field; it's boundaries, plots, and implementation. A colour map can be used as a source for monitoring large-scale fields on the misuse of resources such as seeds, fertilizers, land, and cultivation methods.

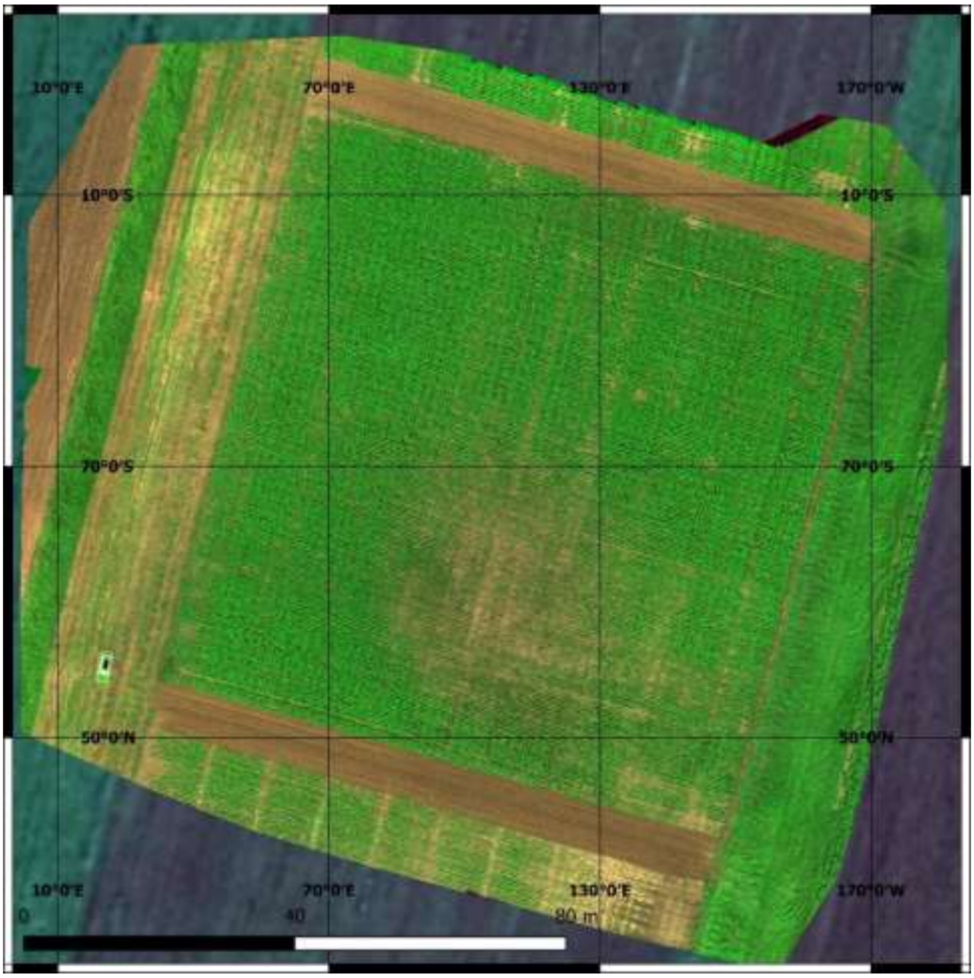

Figure 5: RGB map

Today, one of the most popular tools for working with mineral nutrition of plants is the vegetation index. The calculation of the normalized differential vegetation index (NDVI) is available from the ground - a hand-held device, a satellite - but the satellite is not always in the right place and at the right time, besides a high dependence on clouds and the high costs of images [8]. A UAV is a quick and accurate solution in obtaining such images. NDVI is preferred for global monitoring of vegetation because it helps to compensate for changes in lighting conditions, surface slope, exposure, and other external factors.

Using the camera, we were able to take images in different spectra and applied the index calculation using the formula to get the NDVI map. After the processing step, we draw a map to visualise vegetation activity over the field (Fig. 6). The red colour indicates ground on this image, and green to yellow – greenery activity of crop, the greener it is, the higher the activity. Lack of vegetation in the middle of the field was shown. From this image, we determined where the vegetation is absent, and also where it is stronger and weaker. NDVI is most effective when used to analyse large areas of land for vegetation density and how green a crop appears. It enables evaluation of the health of crops, the effectiveness of cultivation and seeding rates. Vegetation indices, such as the NDVI, are commonly used to contrast the stronger chlorophyll absorption of red wavelengths with the higher reflectance of NIR wavelengths [7].

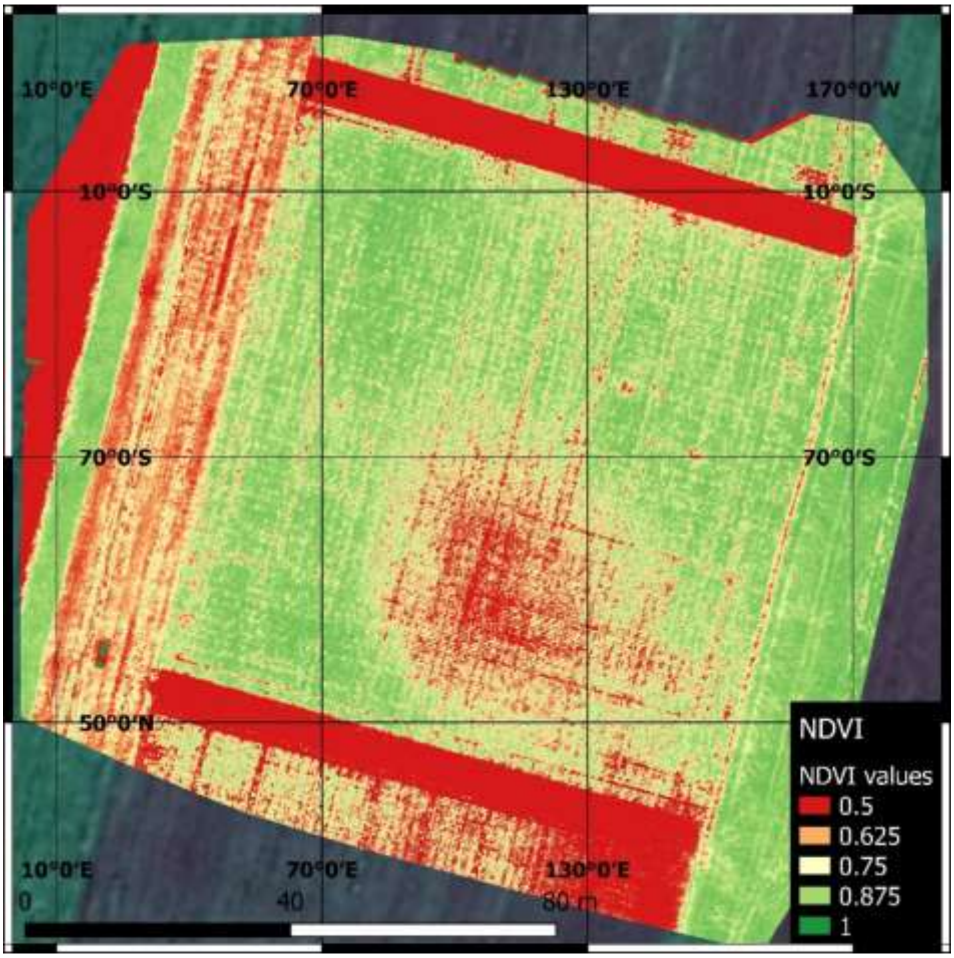

Figure 6: NDVI map

Analysis of the unevenness of the terrain has an important role at the beginning of the agronomic cycle. As a result of the flight, accurate three-dimensional map with uneven terrain was obtained, this analysis is also essential when planning crops and designing irrigation systems. When conducting an agrochemical analysis of the soil together, data are provided to control irrigation and the level of minerals in the fertile layer.

The spatial mapping of terrain objects on the map has one significant limitation, the complexity of taking into account the relief of land plots [5]. Therefore, the availability of information on real relief allows us to solve many problems of agriculture and forestry.

The elevation data was obtained from Geo-TIF images with many locations on the ground, multiple images covered each point. Based on these estimations, we acquired a precise DSM with elevation data. The elevation was calculated in QGIS by building a digital model with meters above sea level (MASL) based on GPS and compass position (Fig. 7).

We analyzed elevation data on the site and identified a deviation. A 2.88% slope was observed from the elevation data, which had a maximum of 160.16 meters and a minimum of 156.7 meters above sea level. The gentle angle of the slope affected water running downhill, which gained energy during heavy rain as it continued to move due to the earth's gravitational pull. This transported the nutrient-rich organic matter in the topsoil down the slope. On the other hand, the formed pits contribute to an intense flooding and over-moisturising of the soil, which negatively affects the development of vegetation.

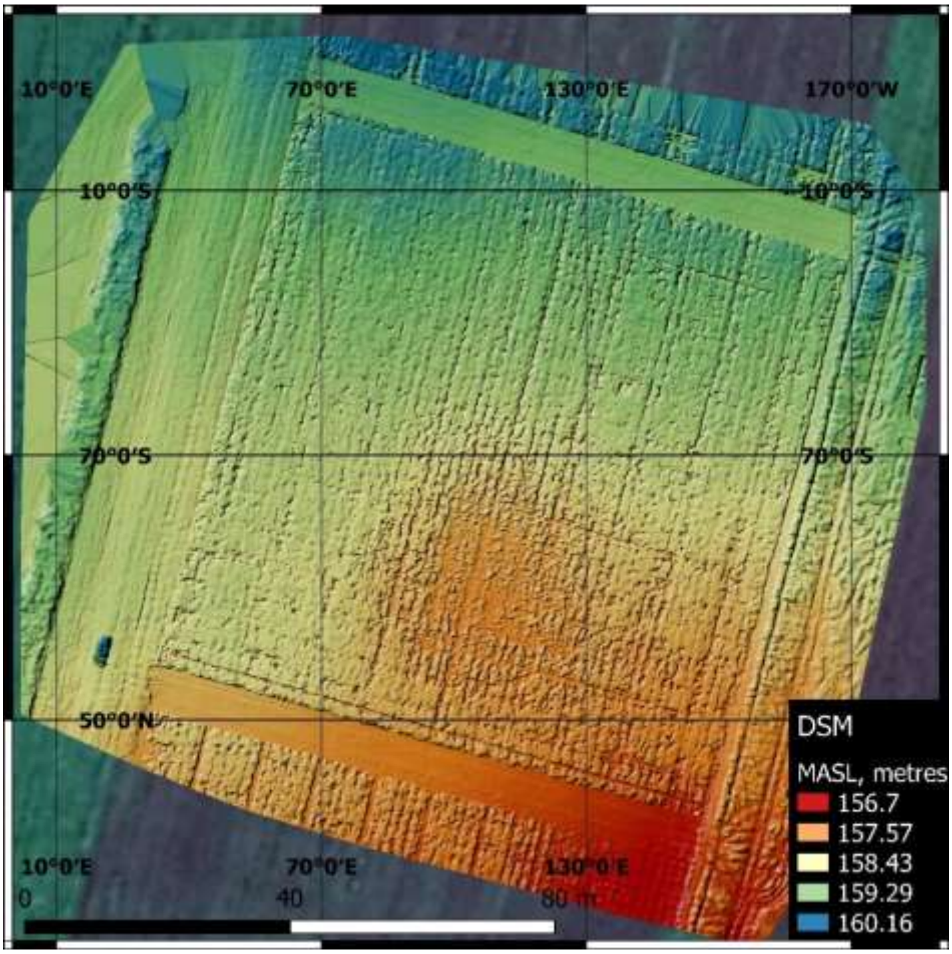

Figure 7: DSM map

5 Conclusion

Using digital mapping methods, we evaluated the terrain and showed the use of UAV and camera in the Amur region. UAVs provide field surveying and high-resolution monitoring, which allow estimating different data. We made layers such as RGB, NDVI and elevation to expand the understanding of the application of these technologies. In the course of the experiment, depressed vegetation was clearly shown. This is applicable for research on large-scale fields where it is impossible to trace the occurrence of problem areas from the ground. We have introduced the methods of processing, imaging and mapping, which is a novelty in the region. In the future, we plan to make experiments in the direction of forecasting the yield of soybeans and other crops using these technologies.

Acknowledgments

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