PHOTOGRAMMETRICALLY ASSESSED SMALLHOLDER PINEAPPLE FIELDS IN GHANA USING SMALL UNMANNED AIRCRAFT SYSTEMS #9439

Marius Hobart[1], Eugene Anin-Adjei[2], Emmanuel Hanyabui[3], Godwin Badu-Marfo[2], Nina Schiller[1], Michael Schirrmann[1]
[1]Leibniz Institute for Agricultural Engineering and Bioeconomy e.V. (ATB), Potsdam, Germany. [2]DEXAFRICA LIMITED, Accra, Ghana. [3]University of Cape Coast, Cape Coast, Ghana
e-mail: mhobart@atb-potsdam.de; tel. +49 (0)30 56 99 432

ABSTRACT

Ultra-high-resolution imagery taken by small, unmanned aircraft systems (sUAS, drones) has been proven beneficial for the monitoring of agricultural crops in conventional farming especially in the context of precision farming. For smallholder pineapple cultivation, the use of sUAS imagery is still sparsely evaluated. However, technical developments in low cost sUAS-sensor combinations make assessments of agricultural areas by service providers more and more affordable for Africa. In this study, we assessed pineapple fields of smallholder farmers in Ghana with sUAS imagery based on a multispectral-thermal camera combination.

In this preliminary study, first results show that this promising technology will have great advantages for the monitoring of pineapple fields in Ghana. The resulting sUAS imagery show distinguishable single pineapple plants for red, green, and blue (RGB) and normalized difference vegetation index (NDVI). Thermal resolution was less detailed but provided a good overview of surface temperatures. The imagery would enable plant-wise level processing of agronomic parameters to assess e.g., plant health. Another option is to use resulting 3D point clouds for the structural analysis of the terrain for a broader landscape assessment, e.g., geomorphology or erosion. This might also help to estimate ecosystem services affecting the pineapple fields in more detail than with sparse reference ground information or poorly resolved satellite imagery. Because sUAS provides so much more details for monitoring, this easy-to-use technique should be used more widely in the context of small-scale agriculture.

Keywords: Remote Sensing, Multi spectral, Thermal, Ortho image, 3D point cloud, Smallholder farmer, Pineapple, Ghana

INTRODUCTION

The usage of small unmanned aerial systems (sUAS) for precise agricultural practices became increasingly common over the last years. Among other approaches it is used for field mapping, plant stress detection, biomass estimation, weed management, inventory counting and chemical spraying (Hassler and Baysal-Gurel, 2019; Khanal et al., 2020). One reason for this development is the drop in prices for the sUAS hardware and belonging sensors (Szczepanski and Purushothaman, 2021) but also a more user-friendly handling for recently developed drones grant access to this technology for more and more users. Further, this technology is mostly independent from power or internet connection on field and can therefore be used in remote areas. All these advantages and the possibilities in knowledge gain make the use of sUAS for smallholder pineapple farms in Ghana beneficial.

MATERIALS AND METHODS

Seven organic and seven conventional farmed fields were assessed in the Central region in Ghana. In summary, all sites cover an area of more than 6 ha for organic and more than 2 ha for conventional fields. Flights with the sUAS were conducted at an altitude of 100 m above ground level and nadir images were taken with a multispectral and thermal sensor combination (Altum, MicaSense, USA). The 3.2 mega pixel sensor used a lens with a focal length of 7.84 mm for spectral and 1.77 mm for the thermal sensor and consisted of 5 spectral bands (blue, green, red, red edge, near infrared) as well as a thermal infrared band. The centered spectral bandwidths were 475, 560, 668, 717, 842 nm and 8-14 µm for the thermal sensor. This setting allowed a ground sample distance of about 4.4 cm/pixel and 67.5 cm/pixel, for spectral and thermal bands, respectively. The sensor was attached directly to the drone (Matrice 300 RTK, DJI, China) without a gimbal. The collected images were taken with an ≥80% forward and side-overlap and subjected to structure-from-motion photogrammetry to create ortho images and 3D surfaces for RGB, NDVI and thermal data of the pineapple fields.

RESULTS AND DISCUSSION

Visual

Multispectral datasets from smallholder pineapple fields can be used for different approaches. It is possible to create undistorted ortho images of the visual RGB spectrum granting an overview of the fields in general, plant density or spot disease symptoms. The latter is possible for data collected from flights with lower altitudes providing higher ground sample resolution. However even these UAV flights in 100m altitude provide plant specific insights.

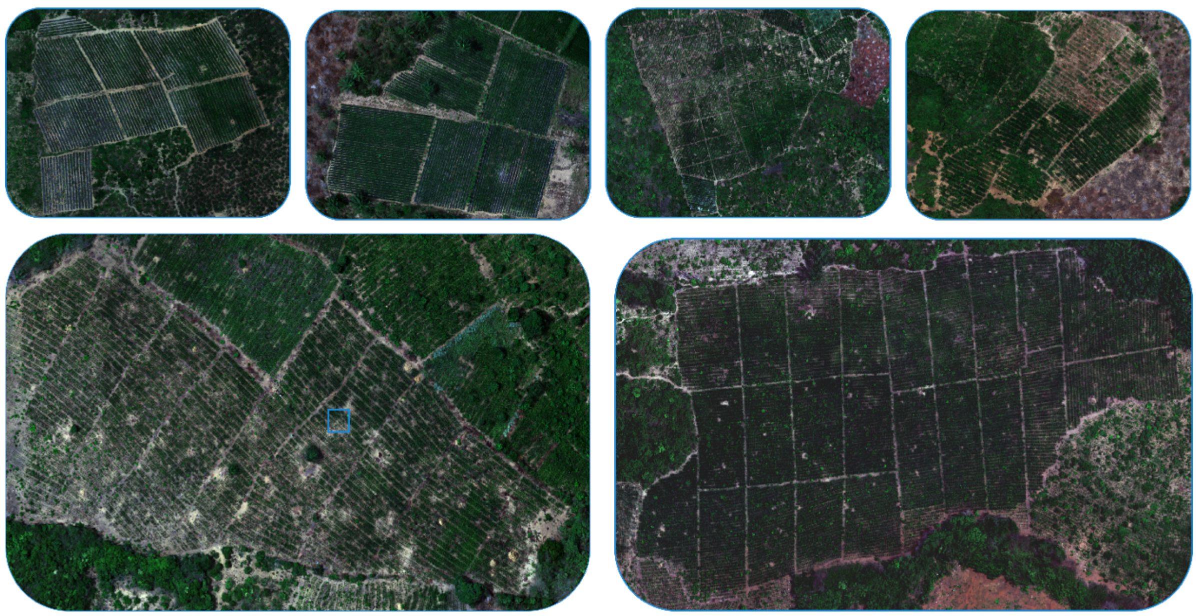

Fig. 4. RGB ortho images of smallholder farmer pineapple fields in central region, Ghana (Field A – down, left; Field B – down, right). Area marked with blue square is shown in detail in Fig. 5.

Spectral indices

Visual information can be helpful to get a good overview of the fields. However, to highlight areas of stressed plants spectral indices will be used. One of the accessed indices here was the NDVI, which refers to the general plant health. It is calculated by the equation $NDVI =$

$\frac{NIR-Red}{NIR+Red}$, for which *NIR* refers to the reflectance information from the NIR channel and *Red* refers to the reflectance value from the red channel. As shown in Fig. 5, this index grants a good overview of plant health status over a field and is therefore able to identify areas of different environmental conditions. This information can help with management decisions, treatments and lay the basis for site specific approaches.

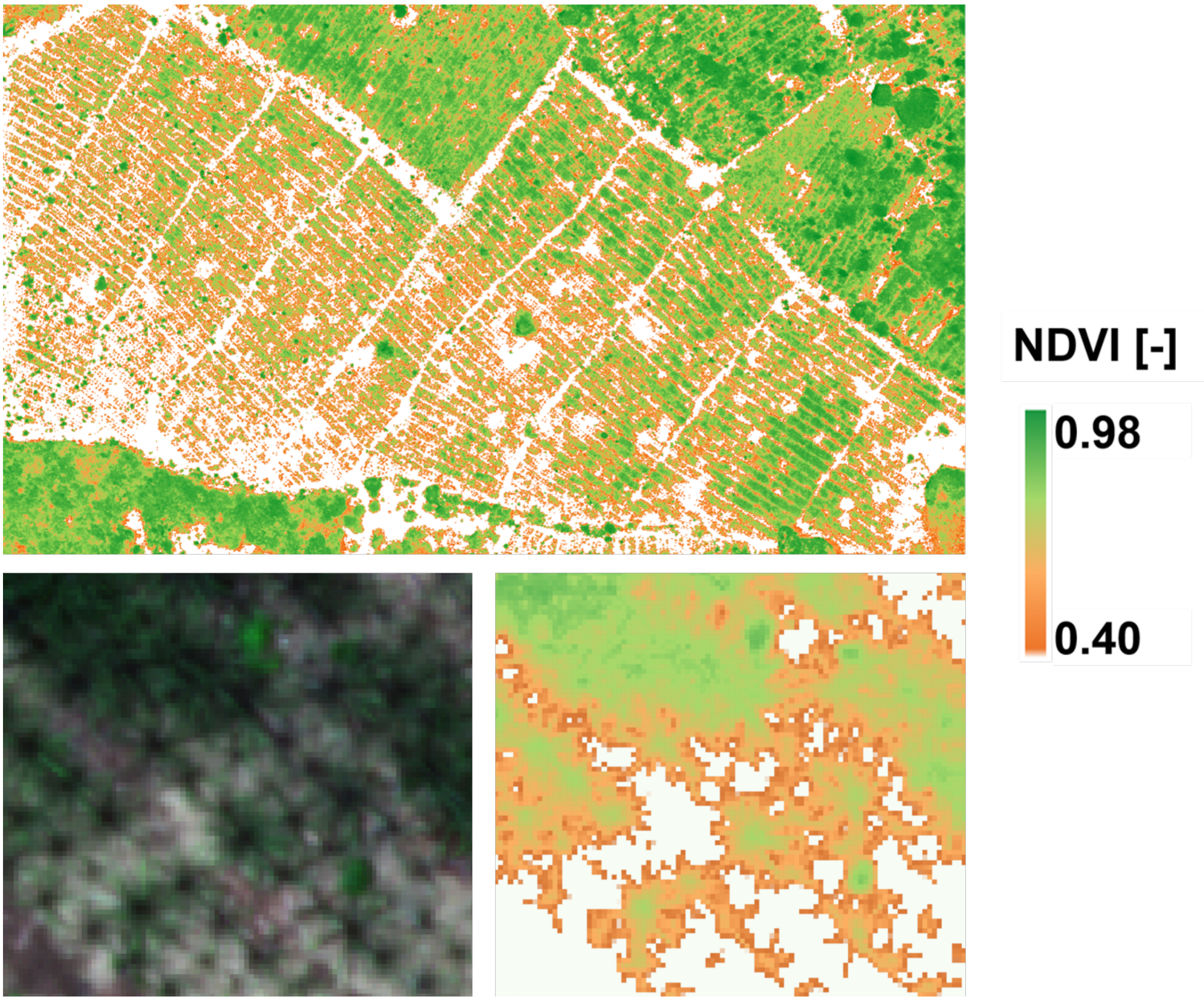

Fig. 5. NDVI calculated for field A from ortho image shown in Fig. 1 (top) and a magnified detail view for RGB (bottom, left) and NDVI (bottom, right) results.

In Fig. 5 a magnified view of field A is given for RGB and NDVI data. You can identify plant rows and spots of denser and sparser plant coverage. Also, you can see that the spectral bands of this assessment method provide a sufficient resolution to extract plant specific information from the datasets.

Another spectral index commonly used is the leaf chlorophyll index (LCI). It is similar to the NDVI but adds some information of the reflectance around the red edge into the equation. It is calculated by $LCI = \frac{NIR-Red\ edge}{NIR+Red}$, for which *NIR, Red Edge* and *Red* refers to the reflectance information from the NIR, the red edge and the red channel, respectively. The LCI grants better information on chlorophyll content but has some limitations for areas without a closed plant canopy. Neither less, also this spectral index can provide a good overview for smallholder pineapple fields. It shows areas of better grown, more dense pineapple plants and areas of weaker growth, as shown in Fig. 6.

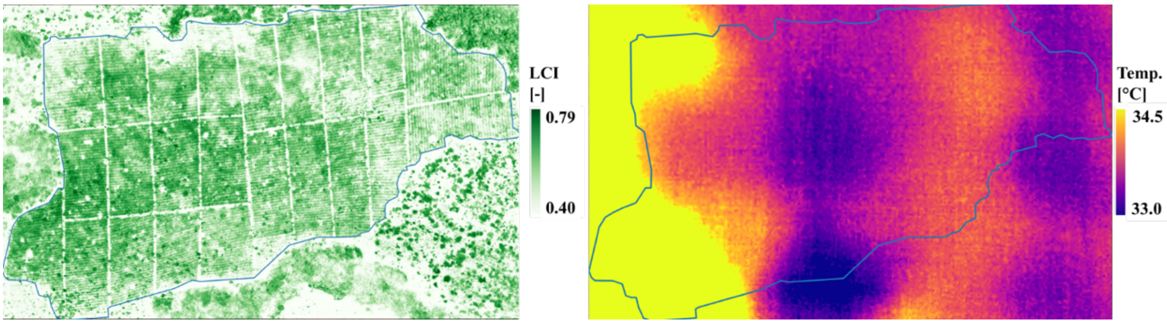

Fig. 6. LCI (left) and temperature data (right) calculated for field B from ortho image shown in Fig. 1.

Thermal

Another useful source of information can be delineated from thermal data. It can be useful for field adapted irrigation and provide information about microclimate data. Thermal data in agricultural landscapes are closely linked to water needs and drought stress of crops. However, the used sensors in this regard are not as highly resolved as spectral bands. For that reason, just overview information areas within the field can be drawn from UAV based thermal data assessments, as shown in Fig. 6. To provide better insights lower flight altitudes will lead to a higher resolution.

CONCLUSION

The variety of UAV based sensor information and the small effort that is necessary to achieve these data make this technology increasingly common in agriculture. Also, for pineapple smallholder farmers sUAS grant a huge potential for monitoring and site-specific approaches. When conducted by a third-party service provider the deployment is minimal effort, quick and should be affordable. Investment returns for these services can be achieved from better quality of the produce and therefore higher prizes as well as higher yields or resource savings for less productive field areas. Even overview flights conducted in high altitudes provide plant specific spectral information. Delineated spectral or thermal information can be used to define different management areas. Further this highly efficient technology can lay the data basis for site specific approaches.

REFERENCES

Hassler, S.C., Baysal-Gurel, F. 2019. Unmanned aircraft system (UAS) technology and applications in agriculture. Agronomy 9(10), 618.

Khanal, S., Kc, K., Fulton, J. P., Shearer, S., Ozkan, E. 2020. Remote sensing in agriculture—accomplishments, limitations, and opportunities. Remote Sensing 12(22), 3783.

Szczepanski, C.J., Purushothaman, R. 2021. Sensors for UAVs dedicated to agriculture: current scenarios and challenges. Aircraft Engineering and Aerospace Technology.