Concept for Sharing Drone Data in Agricultural Data Ecosystem

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***Abstract*—In recent years, drones have made their way onto farms, but the challenge is still to make them an efficient work tool. These drones offer different applications, such as crop monitoring, pest identification, or optimized fertilizer use.**

This paper introduces the formation of the drone concept, where the farmer collects data for his own use, but at the same time, it creates the possibility of sharing and license data for the use of others. This enables the multiuse of data, in which case it creates a new business opportunity for the farmer and, on the other hand, also a new source of data for researchers or other data users to perform data analyses. The other parts of the concept enable for example data sharing and visualization of authorized data, or sharing to closed community. Finally, the next steps of the concept have been discussed, for example automatic drone stations, better discoverability of data, and data reuse. The drone ecosystem in agriculture is not just about technology. It's a blend of technologies, data analysis, and sustainable farming practices.

Keywords*—*Drone, data ecosystem, collaboration

I. Introduction

A. Context for the Research

Agriculture is rapidly developing in a more technological direction. Smart agriculture has been discussed for decades, but only now are we moving to the stage where digital devices are used more widely in the implementation of digitalization. Smart agriculture has been identified as an important theme, which should be systematically developed further. For example, in Finland, a road map of smart agriculture has been produced, an updated version of which has been published at the beginning of 2024 [1].

According Wolfert [2], the future of smart farming may lead two extreme scenarious, closed, proprieatry systems or open, collaborative systems. This second offers stakeholders flexibility to choose business partners and also technological things and change the roles and power relations different positions than before. The development of data spaces and EU regulations offer an opportunity to protect those in a weaker negotiating position. In part, this drone case is also implementing this fair development of the data economy.

Drones are also seen as part of this smart farming development, but their input-benefit ratio is not yet in place. It is time-consuming, the amounts of data are huge, and the users need expertise in using drones, software, analyzing data, and implementing results to agricultural cultivation operations. As an external purchasing service, it also does not work properly on the grain side because the cost per hectare has to be low, because of weak profit margins.

On the research side, more precise data is often needed than what open data satellites offer. Drones offer a good opportunity for that, but their use depends on the projects and their priorities and workforce's.

A clear potential need would be to reuse the data, so that farmers could get a monetary value for their data or exchange data to service. Correspondingly, the researchers and developers could get data for the development of their own analyses or statistics.

According to the Food and Agriculture Organization's (FAO) report, efforts should be made to reuse data in agriculture. This requires, among other things, the development of data sharing principles, high-quality data and data licensing. [3]

In the future, drones can be used to investigate more and more different things, which can be a partial solution to the introduction of drones in agriculture [4] [5]. For example, the identification of pests has come a long way, thanks to the development of artificial intelligence. The development of fertilization and spraying accelerates as legislation develops and equipment prices decrease.

In Finland, there are not known any services to collide data producers and data needers. The development of agricultural data spaces will probably bring answers to this, for example, Gaia-X [6]platform development and Data Space Europe data transfer and licensing services [7].

B. Background

The background of this research is the LivingLabData project, which develops collaboration networks of different farms in Finland, contract patterns related to data, and the development and testing of drone and IoT infrastructure. There are very different types of farm collaboration networks: living labs, research farms, teaching farms, and also research and rural advisor organizations' own cooperation patterns with farmers. The operating models of these different networks will be clarified in order to develop the collection and sharing of data according to fair rules, i.e. by developing agreements in this regard. The project is led by the Natural Resources institute and other partners are the Finnish Geospatial Research Institute of National Land Survey of Finland (NLS), ProAgria (rural advisor organization), Tampere University and Savonia (educational institution). [8]

C. Research Questions

The research question is as follows: How can the collecting, sharing, and reuse of drone data be more automated and easier? The goal was to find out how this operating model would work as an ecosystem, where the legal provisions related to the future data regulation would also be clarified. The second thing was to find the motivations and interest of the different operators collaborate in the drone ecosystem. In addition, the rapid development of technology requires the concept to adapt to new technological solutions. That's why it's good to find out the concept of the future as well.

D. Research Literature

IEEE standardizes the framework for drone applications. With regard to data, it defines the results of the operation, including data classification, data collection and processing, data storage and analysis, and data reference format. [9].

Among drone manufacturers, the clearest leader is DJI, which is also highlighted in research use. From these different manufacturers also comes different software for flight planning, execution, and data processing. Doornbros et al. have analyzed in particular the research of camera use, which is the very most commonly used research area with drones. According to them, the quality of research should be improved in order to better evaluate the use of drones in different industries. [10]

Tsourous et al. have looked in particular at the precision software offering, which they reviewed in their paper up to 100. Drones were expected to play a much larger role in agriculture, and one major reason has been that there has not been a standardized workflow and there has been a challenge in the selection and implementation of technologies. [11] Standards will help define data and software compatibility. On the other hand, there is still a clear need for research on data licensing, implement standards and the promotion of data reuse.

The fully automated drone station significantly changes the usability of drones, making the flights more effective, for example if the flying area is the same and repeated several times in the growing season. Recharge process is automated and so are fligts to. According of Grjl et al., the weaker development of batteries has increased the need to develop drone stations. Development of logarithms have improved their reliability for example in landing. [12] Implementation can be prevented by legislative reasons, which for example prevent flying without drone pilot in Finland. Special permits are required for such activities.

According to Zhang and Zhu, there is a lack of focus on multi-source data fusion in drone remote sensing research. They suggested that fusing data from different sources like LiDAR and RGB could be important for future development. [13]

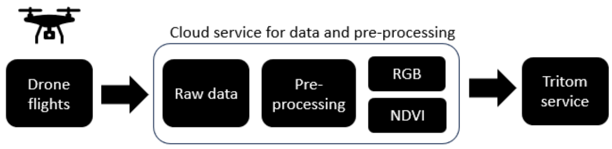

Fig. 1. Drone concept, step A

E. Paper's Structure

The structure of the paper is as follows. First, the Drone concept parts are described including the whole chain. Next, the parts of the drone ecosystem are described. In the result section has introduced results. In the last section, future research and the realization of the next round have been considered, where we plan to try an automatic drone and data authorization more practical level.

II. Drone Concept

The method of the research has been to collect data every week during growing season from the target educational Mustiala farm, and to use the cloud services of the Finnish computing and cloud service organization (CSC) [14], and to start testing the possibilities of using new of kind data space technologies including trusted data transmission and permission techniques. In this case is researched possibilities to use Tritom-service from Data Space Europe - company [7]. The background research provides the basis for the implementation of the data collection, but there has not been a reference framework for the research, which would have taken into account the implementation of many actors and where data would have been managed automatically from beginning to end. The open source Opendronemap [15] software collections provides a very broad basis for development work and extend features to it.

A. Data Collection and Processing

On the left in Fig. 1, according this paper research concept, there is a farmer, who is a producer of drone data. The practical implementation was on an educational farm, so in practice the farmer in this pilot was a student of agriculture. The drone pilot took the required drone courses in order to get permission to fly in Finland. In the pilot case, she used a basic drone with multispectral camera provided by NLS. The field block was purposely located next to the educational farm so that the implementation would be easy and the later phase pilots could also be implemented more easily when electricity and internet connection were available. Data were collected weekly throughout the harvest season. The huge amount of raw data was transferred to CSC's cloud service, which had the NLS's own server.

On the server, the raw data has been processed with the Opendronemap [15] application, which allows separate images to be combined into one image a field. RGB and NDVI images were created from the data. RGB is a normal

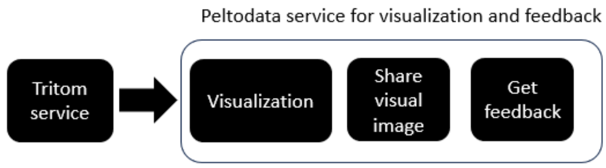

Fig. 2. Drone concept, step B

image, and NDVI describes the vegetation index, i.e. the amount of leafy green. Due to the large amount of raw data, in the pilot, there was a question about whether it makes sense to keep the raw data and whether there would be a certain period of time after which it would be automatically destroyed. In practice, there should be no reason to keep the original data if the processed images are of high quality and metadata information has also been produced.

The CSC service allows share files in different ways. In this case, the generation of unique keys for the files was to to control access to the files.

The preliminary plan was to connect the Tritom data transmission service to the data chain as well. However, this would have required the installation of the function also in the CSC service, which was not yet implemented in this round. There were also challenge of handle larger than 10 megabytes files with that. Tritom was tested as such, and good experiences were already gained for the next pilot round and there are ideas to control larger files. That is why, Tritom or another similar trusted transfer and authorization services will be kept in concept.

B. Data Visualization and Feedback

In the rest of the pilot in Fig. 2, data visualization was tested in another service. The idea is that in the future the farmer can also have his own data stores or the data is somewhere else in the cloud service. In this case used the prototype platform, peltodata.fi-service, [16] which has been developed in different projects and its purpose is specifically to test new technologies, new analyses or implementation models. In this particular case, the drone data was transferred to Peltodata andthe data was visualized for the user from there. The idea of using Peltodata is based writers experiences of that own service. In the next stages of the concept, instead of Peltodata, there can be other back and front end service combination.

A community data sharing service had also just been developed for the service in question, which enabled the user to share a view of the desired data with the desired person. The person in question was then able to comment on the data in question. This function is a step towards anyone being able to play the role of an advisor who just knows how to help interpret the data.

III. Ecosystem

A. Data

At the center of the drone ecosystem is data. This means that many things must be agreed on. There should be sufficient demand for data from researchers, companies or authorities. Of course, the farmer can only produce for his own use without certainty about the reusers of the data. Data quality should be verified and recorded as accurately as possible. The user of the data then assesses its adequacy for his use. At best, the data user would publish their own analyses, or at least their individual data needs and their more detailed information, so that the data producers could produce them with sufficient accuracy. Each analysis may need data with, for example, different resolutions, camera technologies, time intervals, and positioning accuracy. This kind of collaboration between data users and data producers would be a very necessary development target for the development of the agricultural drone ecosystem.

The challenge with drone data is the large amount of raw data. Before edge computing works effectively at the edge of the field, services are needed where data can be easily entered and reprocessed into sensible formats. Of course, there are such services, but in the case of a broader data economy, the transfer of data and authorization for use by others must also be taken into account. In the commercial versions, this data usually still seems to stop at that application at the moment. The development of standards and the data space architectures will hopefully change the situation for the better.

B. Contract Model

A key part in the development of a sustainable operating method for the drone data ecosystem was to also start developing the contract model. This preliminary version of the contract was made and took into account, in particular, the fair data economy of agriculture, which had been worked on for a couple of years in Finland on the IFDEA project [17] with numerous different actors in twenty different workshops. The contract included the roles of different actors in this ecosystem. The challenge was to determine a central agreement from a fairly large group of actors. The agreement also included the soon to be implemented EU regulations, such as the data act [18].

C. Motives and Interest of Concept

During the development of the concept, the motives and interests of various operators came to the fore to implement the drone concept. These topics have been discussed at various meetings, in agricultural machinery exhibition, and in mutual discussions. Farmers requested more efficient and easier use of drones. Perhaps the most common wishes were that the drone could be used to identify harmful plants in order to make their collection and removal easier. The reuse of data aroused interest when the possibility arose to also receive compensation for data either in money or as a service.

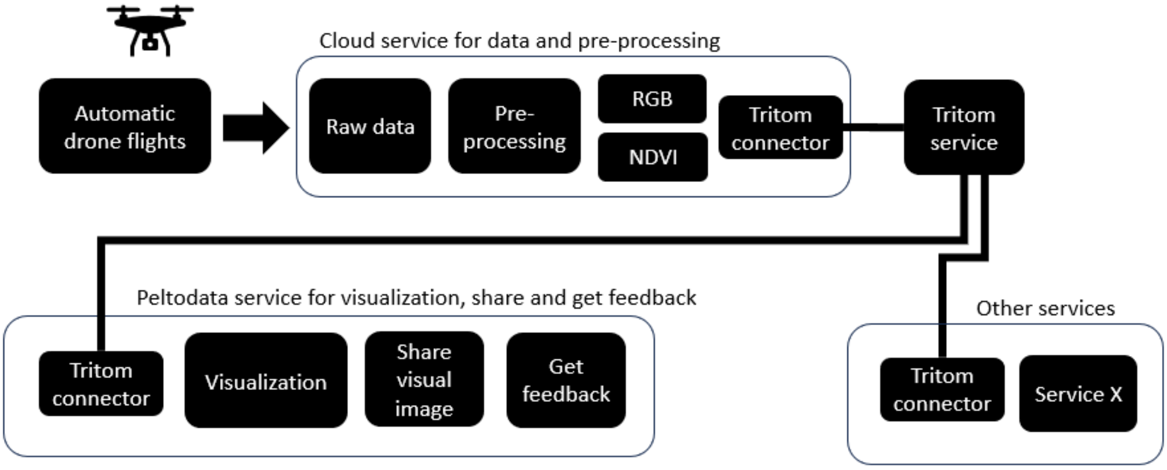

Fig. 3. Drone concept, future work

From the direction of the researchers, hopes arose to get time series data and data taken with special cameras. The evaluation of carbon footprint measurement was something that emerged in the hopes of several researchers. In general, drone data alone were not sufficient for the development of analyses, but other data sets would also have been needed.

NLS was developing this concept, which handled the pre-processing of the data. The development of drones is part of the goals of this organization, so more and more automated data collection is the goal, so research work is increasingly focused on data analysis instead of field work.

In this test case, the farm was represented by the educational farm. Their goal is to obtain concrete teaching examples in the direction of the students. Such living lab-type educational farms play an important role in the transmission of information and the introduction of new methods, and also as an enabler in terms of testing new equipment. Regarding basics farms, there can easily be limitations to contribute large pilots disturbing the operation of the farm too much.

The data transmission operator was interested in getting a new kind of use case from this, especially a case with a challenging amount of data.

The Tampere university developed a front-end function where data can be visualized for the farmer and possibly also for other authorized parties. The university was the main developer of the concept. The goal of this operator was to get the data infrastructure working so that the data producer and the data users could find each other and thus speed up the development of analyses, while less time is spent collecting data.

The developer of the concept was also company of 1001 Lakes which focused on fair data and EU regulations, which designed a preliminary contract paper suitable for the ecosystem, which took into account several parties and future regulations and the rule book of the fair data economy in agriculture.

IV. Results

This work describes the iteration of the first round of drone data ecosystem, based on which experience has been gained in different areas related to the ecosystem and the necessary new development targets for the next iteration round.

The result of the work was a preliminary agreement of the drone data ecosystem, which already took into account the new EU regulations and the rules of a fair data economy in agriculture. During the research, the development targets for the next round were revealed.

During the research, it was found out the motivations of various operators for the implementation of such a concept.

The results showed that it is possible to implement the multi-actor drone concept. Opendronemap turned out to be a very good further development tool that can be used to develop automated data management and processing. As a result of the work, there was a clear need for a automatic drone station, which can facilitate the workflow and solve the problem of battery consumption. These results support previous studies, where the challenge has been the construction of a data pipeline, the work time required for the entire process and also consumption of batteries.

The goal of next iterations is to develop a working concept from this, where the farmer can produce data for different operators and receive monetary or other compensation for it. Researchers, on the other hand, could give orders to farmers so that they could get the data they need for their research.

V. Future Work

The next pilot round of implementation is planned to include the following things, which is described in Fig. 3. A significant development step is testing a fully automated drone unit. The field was chosen based on its location, where there is a nearby building with electricity and Internet connection. These are needed for the automatic drone unit. The drone flights would therefore no longer be made by the farmer himself, but he would be more in the role of a supervisor that everything works technically and safely. Finland's aviation law still prevents fully autonomous drone base stations.

The Tritom data transfer service is being tested and tried more on a practical level and we are trying to get the data authorized through it. This may require installing Tritom on the CSC service for the pattern to work. File key management also needs to be solved in this context so that it can be automated or managed in some other way. Next round is needed also solve metadata transfers and final files large size challenges. For example, would it be good to create preview images for the CSC service, so that it would be easier to visualize the data in the front-end service without having to transfer large files first? Then there would no need to create for example Geoserver-type back-end service for sharing images to the web service.

As a project, Livinglabdata is not developing analyses, but infrastructure and the formation of ecosystems and the reuse of data. The other measurements in the field have been planned with the needs of other organizations' projects in mind, which have analyses developments ongoing. In this way, a basis is created for the practical realization of data reuse across organizational boundaries.

A contract model was developed for the first round, which took into account the roles of different actors and future EU data regulations and fair data rules. This contract model did not have time to be validated in the first round, so this is the task of the next round. The goal is that the production and sharing of data would be easier in the future when ready-made contract models for the use of drone data ecosystems were available. Based on these, it is easier to agree on suitable compensations or e.g. exchange of services, so that the various operators are satisfied.

An area of future development could be to be able to give specific assignments to farmers, which they could perform according to the contract and would receive compensation for the data produced. There is no such service yet, but as data spaces develop, such services may start to appear.

This drone data ecosystem will be further developed in such a way that it will be able to respond to the motives of different actors for the construction and development of the ecosystem.

References

[1] L. Pesonen, P. Linna, K. Pussi, O.-P. Ruponen, and T. Teinilä, "Älymaatalouden tiekartta," https://maaseutuverkosto.fi/agrihubi/aiheet/alymaatalous/mita-on-alymaatalous/, 2024, accessed: 2024-01-20.

[2] S. Wolfert, L. Ge, C. Verdouw, and M.-J. Bogaardt, "Big data in smart farming – a review," *Agricultural Systems*, vol. 153, pp. 69–80, 5 2017, s. Ge. L. Wolfert, C. Verdouw and M.-J. Bogaardt, "Big Data in Smart Farming – A review" 2017, Agricultural Systems, 153, 69–80. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0308521X16303754

[3] FAO, *Farm data management, sharing and services for agriculture development*. FAO, 2021. [Online]. Available: https://doi.org/10.4060/cb2840en

[4] T. Lipping, P. Linna, and N. Narra, *New developments and environmental applications of drones*. Springer, 2022.

[5] T. Westerlund and J. Peña Queraltal, *New developments and environmental applications of drones*. Springer, 2024.

[6] "Gaia-x," https://gaia-x.eu/, accessed: 2024-01-20.

[7] "Data space europe," https://www.dataspace.fi/en/data-intermediation-service, 2024, accessed: 2024-01-20.

[8] https://www.maanmittauslaitos.fi/en/research/livinglabdata, accessed: 2024-01-20.

[9] "Ieee standard for drone applications framework," *IEEE Std 1936.1-2021*, pp. 1–28, 2021.

[10] J. Doornbos, K. E. Bennin, Babur, and J. Valente, "Drone technologies: A tertiary systematic literature review on a decade of improvements," *IEEE Access*, vol. 12, pp. 23 220–23 239, 2024.

[11] D. C. Tsouros, S. Bibi, and P. G. Sarigiannidis, "A review on uav-based applications for precision agriculture," *Information*, vol. 10, no. 11, 2019. [Online]. Available: https://www.mdpi.com/2078-2489/10/11/349

[12] C. G. Grlj, N. Krznar, and M. Pranjić, "A decade of uav docking stations: A brief overview of mobile and fixed landing platforms," *Drones*, vol. 6, no. 1, 2022. [Online]. Available: https://www.mdpi.com/2504-446X/6/1/17

[13] Z. Zhang and L. Zhu, "A review on unmanned aerial vehicle remote sensing: Platforms, sensors, data processing methods, and applications," *Drones*, vol. 7, no. 6, 2023. [Online]. Available: https://www.mdpi.com/2504-446X/7/6/398

[14] CSC, "Csc," https://csc.fi/, 2024, accessed: 2024-01-20.

[15] OpenDroneMap, "Opendronemap," https://www.opendronemap.org/, 2024, accessed: 2024-01-20.

[16] P. Linna, N. Narra, and J. Gronman, "Intelligent data service for farmers," in *2019 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*. IEEE, May 2019, pp. 1072–1075. [Online]. Available: https://ieeexplore.ieee.org/document/8756688/

[17] "Implementing fair data economy in agriculture (ifdea)," https://www.tuni.fi/fi/tutkimus/ifdea, accessed: 2024-01-20.

[18] "Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act)," Dec. 2023, legislative Body: CONSIL, EP. [Online]. Available: http://data.europa.eu/eli/reg/2023/2854/oj/eng