

Diploma Thesis

3D Drone Tracking

Image-Driven 3D Drone Tracking employing Multiple Stations for Agricultural Use

Submitted by

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Kurzfassung / Abstract

Eine Kurzfassung ist in deutscher sowie ein Abstract in englischer Sprache mit je maximal einer A4-Seite zu erstellen. Die Beschreibung sollte wesentliche Aspekte des Projektes in technischer Hinsicht beschreiben. Die Zielgruppe der Kurzbeschreibung sind auch Nicht-Techniker! Viele Leser lesen oft nur diese Seite.

Beispiel für ein Abstract (DE und EN)

Die vorliegende Diplomarbeit beschäftigt sich mit verschiedenen Fragen des Lernens Erwachsener – mit dem Ziel, Lernkulturen zu beschreiben, die die Umsetzung des Konzeptes des Lebensbegleitenden Lernens (LBL) unterstützen. Die Lernfähigkeit Erwachsener und die unterschiedlichen Motive, die Erwachsene zum Lernen veranlassen, bilden den Ausgangspunkt dieser Arbeit. Die anschließende Auseinandersetzung mit Selbstgesteuertem Lernen, sowie den daraus resultierenden neuen Rollenzuschreibungen und Aufgaben, die sich bei dieser Form des Lernens für Lernende, Lehrende und Institutionen der Erwachsenenbildung ergeben, soll eine erste Möglichkeit aufzeigen, die zur Umsetzung dieses Konzeptes des LBL beiträgt. Darüber hinaus wird im Zusammenhang mit selbstgesteuerten Lernprozessen Erwachsener die Rolle der Informations- und Kommunikationstechnologien im Rahmen des LBL näher erläutert, denn die Eröffnung neuer Wege zur orts- und zeitunabhängiger Kommunikation und Kooperation der Lernenden untereinander sowie zwischen Lernenden und Lernberatern gewinnt immer mehr an Bedeutung. Abschließend wird das Thema der Sichtbarmachung, Bewertung und Anerkennung des informellen und nicht-formalen Lernens aufgegriffen und deren Beitrag zum LBL erörtert. Diese Arbeit soll einerseits einen Beitrag zur besseren Verbreitung der verschiedenen Lernkulturen leisten und andererseits einen Reflexionsprozess bei Erwachsenen, die sich lebensbegleitend weiterbilden, in Gang setzen und sie somit dabei unterstützen, eine für sie geeignete Lernkultur zu finden.

This thesis deals with the various questions concerning learning for adults – with the aim to describe learning cultures which support the concept of live-long learning (LLL). The learning ability of adults and the various motives which lead to adults learning are the starting point of this thesis. The following analysis on self-directed learning as well as the resulting new attribution of roles and tasks which arise for learners, trainers and institutions in adult education, shall demonstrate first possibilities to contribute to the implementation

of the concept of LLL. In addition, the role of information and communication technologies in the framework of LLL will be closer described in context of self-directed learning processes of adults as the opening of new forms of communication and co-operation independent of location and time between learners as well as between learners and tutors gains more importance. Finally the topic of visualisation, validation and recognition of informal and non-formal learning and their contribution to LLL is discussed.

Gliederung des Abstract in **Thema, Ausgangspunkt, Kurzbeschreibung, Zielsetzung**.

Projektergebnis Allgemeine Beschreibung, was vom Projektziel umgesetzt wurde, in einigen kurzen Sätzen. Optional Hinweise auf Erweiterungen. Gut machen sich in diesem Kapitel auch Bilder vom Gerät (HW) bzw. Screenshots (SW). Liste aller im Pflichtenheft aufgeführten Anforderungen, die nur teilweise oder gar nicht umgesetzt wurden (mit Begründungen).

Declaration of Independent Work

STATUTORY DECLARATION

I hereby declare under oath that I have composed the present work independently and without external assistance, have not used any sources and aids other than those specified, and have identified as such the passages extracted literally and in content from the sources used. My work may be made publicly accessible if there is no confidentiality notice.

Place, Date

Author 1

Place, Date

Author 2

Contents

Abstract	ii
1 Introduction	1
1.1 Detailed Task Description	1
1.1.1 Student Name 1	1
1.1.2 Student Name 2	1
1.2 Documentation of the Work	1
2 Market Analysis	3
2.1 Industry Overview and Market Potential	3
2.1.1 Applications of Drones in Agriculture	3
2.1.2 Market Growth and Potential	3
2.1.3 Challenges and Opportunities	4
2.2 Target Group Definition	4
2.3 Buyer Personas	5
2.4 Competitor Analysis	6
2.5 Conclusion	8
Bibliography	17

1 Introduction

In the introduction, it is explained why this topic was chosen. (Objectives and tasks of the overall project, technical and economic environment)

1.1 Detailed Task Description

1.1.1 Student Name 1

1.1.2 Student Name 2

1.2 Documentation of the Work

The project results are documented.

- Basic concept
- Theoretical foundations
- Practical implementation
- Solution approach
- Alternative solution approach
- Results including interpretation

Further suggestions:

- Manufacturing documents
- Test cases (measurement results...)
- User documentation
- Used technologies and development tools

2 Market Analysis

2.1 Industry Overview and Market Potential

Drones are transforming agriculture by offering innovative solutions to enhance efficiency and sustainability. As reported by Chaundler [3], companies like CO₂ Revolution are using drones to plant seeds in inaccessible areas, showcasing the potential of drone technology in reforestation and agricultural applications.

The global agricultural sector faces significant challenges, including the need to increase food production to meet the demands of a growing population and to address climate change impacts [12]. Traditional farming methods are often insufficient, leading to a surge in the adoption of drones for various agricultural purposes.

2.1.1 Applications of Drones in Agriculture

Drones are utilized in agriculture for a wide range of applications:

- **Crop Monitoring and Mapping:** Drones provide high-resolution aerial imagery, enabling farmers to monitor crop health, identify pest infestations, and assess soil conditions in real-time [12, 13].
- **Precision Spraying:** Equipped with advanced navigation systems, drones can apply fertilizers, pesticides, and herbicides precisely where needed, reducing chemical usage and minimizing environmental impact [2, 4].
- **Irrigation Management:** Drones assist in detecting variations in soil moisture levels using thermal sensors, helping optimize irrigation systems and conserve water resources [12].
- **Planting and Seeding:** Some drones are designed to plant seeds over large areas efficiently, particularly useful in reforestation efforts and hard-to-reach terrains [3].
- **Data Collection and Analysis:** Drones gather extensive data that, when processed with advanced analytics, provide actionable insights for improving crop yields and farm management practices [14].

2.1.2 Market Growth and Potential

The agricultural drone market is experiencing significant growth. Valued at \$0.88 billion in 2020, it is projected to reach \$5.89 billion by 2030, with a

compound annual growth rate (CAGR) of 22.4% [13]. Key factors contributing to this growth include:

- **Demand for Increased Food Production:** Global population growth drives the need for higher agricultural output, encouraging the adoption of efficient technologies like drones [12].
- **Technological Advancements:** Improvements in drone capabilities, such as enhanced sensors and longer flight times, make them more practical for agricultural applications [2].
- **Adoption of Precision Farming Techniques:** Farmers are increasingly utilizing drones for site-specific crop management to optimize resource use and increase yields [13].

2.1.3 Challenges and Opportunities

While the potential is significant, the adoption of drones in agriculture faces several challenges:

- **Regulatory Barriers:** Strict government regulations on airspace and drone operations can hinder deployment [12].
- **High Initial Costs:** The expense of acquiring and maintaining advanced drones may be prohibitive for small-scale farmers [13].
- **Technical Skills Requirement:** Effective use of drones demands specialized knowledge, which may not be readily available in all farming communities [14].

Opportunities to address these challenges include:

- **Government Support:** Initiatives like Austria's "Smart Farming" action plan aim to integrate digital technologies into agriculture, providing funding and resources to farmers [7].
- **Technological Innovations:** Developing user-friendly and cost-effective drones can lower barriers to entry [2].
- **Education and Training:** Implementing programs to educate farmers on drone technology enhances adoption and effective utilization [12].

2.2 Target Group Definition

Our ideal customers are medium to large agricultural enterprises, service providers, and technology companies focused on modernizing agriculture with drone technology.

Key Characteristics

- **Demographics:** Decision-makers aged 35–60 with higher education in agriculture or business management, often fitting the 'Progressive Realists' or 'Adaptive Pragmatic Middle' Sinus-Milieus [11].

- **Geographics:** Located in agricultural regions such as Lower Austria, Styria, and Upper Austria.
- **Psychographics:** Innovation-oriented, value efficiency and sustainability, open to new technologies.
- **Behavioral:** Research thoroughly before purchases, attend industry events, rely on professional networks.
- **Needs:** Affordable, reliable drone tracking systems to optimize farming operations.
- **Technographics:** Moderate to high technological proficiency, use agricultural management software, active on professional forums.

2.3 Buyer Personas

Persona 1: Thomas Bauer

- **Age:** 52
- **Role:** Owner of a large family farm
- **Location:** Lower Austria
- **Goals:** Increase crop yields and efficiency through technology
- **Pain Points:** High costs of advanced drones; needs affordable tracking solutions
- **Behavior:** Reads industry news, attends agricultural fairs, values practical solutions

Persona 2: Maria Hofer

- **Age:** 40
- **Role:** CEO of an agricultural technology service provider
- **Location:** Graz, Styria
- **Goals:** Expand services with cost-effective drone solutions
- **Pain Points:** Requires reliable tracking without expensive onboard equipment
- **Behavior:** Active on LinkedIn, follows industry trends, seeks scalable solutions

Persona 3: Andreas Schneider

- **Age:** 55
- **Role:** Government agricultural advisor
- **Location:** Vienna
- **Goals:** Promote sustainable farming practices using new technologies
- **Pain Points:** Finding cost-effective solutions for widespread adoption
- **Behavior:** Reads policy papers, influences procurement decisions, values ecological responsibility

2.4 Competitor Analysis

The agricultural drone market is increasingly competitive in Austria and globally, with key players offering advanced solutions for precision farming. This analysis focuses on three major competitors relevant to the Austrian market:

1. **Dronetech (Austria):** An Austrian drone service provider, Dronetech has partnered with Huawei to develop 5G-enabled drone solutions for smart farming. Their collaboration includes equipping drones with high-resolution cameras and sensors, utilizing Huawei's cloud computing and AI capabilities for real-time data analysis. They focus on sustainable farming practices by enabling precise application of water, fertilizers, and pesticides, reducing waste and environmental impact. A notable challenge they face is network coverage limitations for 5G drones [9, 8, 6].
2. **DJI (China):** A global leader in drone technology, DJI Agriculture offers a comprehensive suite of advanced agricultural drones and solutions, including models like the DJI Agras T50 and Mavic 3M. Their products are equipped with advanced sensors, multispectral cameras, and software solutions like DJI Terra for flight planning and data analysis. DJI's drones support various agricultural applications such as crop monitoring, spraying, and mapping. In Austria, DJI's agricultural products are distributed through partners like Drohnenring, providing consultation, sales, training, and support services [5, 1].
3. **AgEagle (USA):** AgEagle Aerial Systems Inc. specializes in drone-based solutions for agriculture, offering products like the eBee X mapping drone and multispectral sensors such as RedEdge-P and Altum-PT. Their technology enables agronomists and farmers to capture high-resolution RGB and multispectral data for applications like yield prediction, crop monitoring, input management, and damage assessment. AgEagle emphasizes the benefits of drone data for increasing yield, reducing costs, and providing season-long insights. They also offer software solutions like eMotion and Measure Ground Control for flight planning and data processing [10].

Competitive Landscape

The agricultural drone market in Austria features both local companies like Dronetech, leveraging partnerships with global tech firms to offer innovative solutions, and international players like DJI and AgEagle, providing advanced drone technology and comprehensive agricultural services. Competition centers on integrating cutting-edge technologies such as 5G connectivity, AI, and multispectral imaging to enhance precision farming practices.

Our Differentiation and Positioning

Our 3D drone tracking system distinguishes itself by offering an affordable and accessible solution that eliminates the need for expensive onboard systems. By utilizing ground-based 3D tracking through calibrated and synchronized stations with advanced image processing, our system allows for the deployment of "dumb" drones—drones without sophisticated onboard tracking equipment.

This approach provides several key benefits:

- **Reduced Drone Weight:** Without heavy onboard sensors and communication equipment, drones can carry additional payloads such as seeds, fertilizers, or pesticides, enhancing their operational efficiency and productivity. This is particularly beneficial for tasks like seed planting or crop spraying, where maximizing payload capacity is crucial.
- **Increased Flight Time:** Lighter drones consume less energy, potentially increasing flight durations and allowing them to cover larger areas in a single mission. This efficiency reduces the number of flights required and saves time.
- **Cost-Effectiveness:** Eliminating the need for expensive onboard systems significantly reduces the overall cost of drone operations. This makes precision agriculture technologies more accessible to a broader range of farmers and agricultural enterprises, including those with limited budgets.
- **Ease of Maintenance:** Simpler drones with fewer onboard components are easier to maintain and have a lower risk of technical failures. This reduces downtime and maintenance costs, ensuring consistent operational capability.
- **Independence from Network Infrastructure:** Unlike competitors relying on 5G connectivity, our ground-based system does not depend on network coverage, which can be limited in rural agricultural areas. This ensures reliable operation regardless of connectivity issues, providing consistent performance in all locations.
- **Scalability and Flexibility:** Our ground stations can track multiple drones simultaneously without adding complexity or weight to the drones themselves. This allows for scalable operations, enabling large-scale agricultural tasks to be performed efficiently.
- **Data Security and Privacy:** By processing tracking data locally through ground stations, there is reduced reliance on cloud services, enhancing data security and privacy. Farmers can have greater control over their data without the concerns associated with transmitting sensitive information over networks.

We position ourselves as a provider of innovative, cost-effective, and practical drone tracking solutions tailored to the specific needs of the agricultural sector in Austria. By addressing key challenges such as high costs, weight limitations, maintenance complexities, and dependency on network infrastructure, our system empowers medium to large agricultural enterprises, service providers, and technology companies to enhance efficiency and sustainability through accessible drone innovations.

Our ground-based approach overcomes limitations such as network coverage, onboard equipment costs, and drone payload restrictions faced by competitors. By focusing on these strengths, we offer a unique value proposition in the agricultural drone market, providing farmers with a practical and efficient tool to improve their operations without requiring substantial investment in complex drone technology.

2.5 Conclusion

The market analysis reveals a significant opportunity for our ground-based 3D drone tracking system in the agricultural sector. As drone adoption in agriculture accelerates, our solution addresses key challenges like high costs and dependence on network infrastructure by eliminating the need for expensive onboard equipment. By enabling the use of simpler, more affordable drones with increased payload capacity, we offer a unique value proposition that differentiates us from competitors. Our system aligns with the needs of medium to large agricultural enterprises seeking efficient and sustainable technologies. Further research and engagement with industry stakeholders will refine our understanding of target customers and support a successful market entry.

Appendix

List of Tables

List of Figures

Listings

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