Contributing to Social Inclusion Through Use Open-Source Drone

SUEDA Koh

Digital Hollywood University, Medeia Science Institute/
SenseFoil Pte. Ltd./Hannan University

This research note explores how open-source UAV (Unmanned Aerial Vehicle) technology can advance social inclusion and sustainable mobility. Our team has used open-source platforms for interdisciplinary projects beyond traditional development boundaries. We have organized anti-poaching drone workshops, remote STEAM education programs, and projects like "Crowminication" and "Third Person Piloting" to solve unique challenges through collaboration. We conducted joint research with EverBlue Technologies on sailing drones, which led to field experiments demonstrating the potential of UAV technology in enhancing sailing accessibility. These findings inspired the "Inclusive Sailing" project, which uses UAV technology to assist sailors of all abilities. These efforts show that open-source platforms can remove barriers related to expertise, resources, and geography, fostering inclusive and collaborative research. Our goal is to continue expanding these activities to engage diverse communities and inspire innovation.

1. Introduction

Our research team has utilized knowledge in computer-human interfaces and interaction design to promote the development of drone (UAV) interfaces and platforms aimed at enhancing drone operation and utilization. This involves both academic and practical efforts, including developing control interfaces, automating unmanned sailboats using open-source UAV (OSUAV) platforms, and conducting international collaborative research on drone applications in STEAM education. By leveraging open-source platforms that encompass technology, community engagement, and problem-solving mechanisms, we have enabled a wide range of interdisciplinary research activities that transcend specialized boundaries. Through these efforts, we have realized that the open-source concept plays a crucial role not only in democratizing research but also in promoting inclusive communication, especially in remote areas or among collaborators who lack specialized know-how.

Globally, there is a growing emphasis on creating an inclusive society that leaves no one behind, as reflected in the Sustainable Development Goals (SDGs). An inclusive society is one where all individuals, regardless of their background or abilities, can participate equally and are respected within the community. The key characteristics of an inclusive society include:

- **Equality of Social Participation:** Ensuring that all people, irrespective of age, gender, disability, economic status, religion, or cultural background, can participate equally in all aspects of society, including education, employment, and civic activities.
- **Respect for Diversity:** Providing an environment where individuals from diverse backgrounds and abilities are respected and where their unique skills and identities are recognized and valued.
- **Accessibility:** Ensuring that physical infrastructure, information, and services are accessible to everyone. This includes providing necessary support or accommodations for those with disabilities or the elderly to lead independent lives.
- **Empowerment:** Supporting socially marginalized groups in understanding their rights and actively engaging in society. This includes offering education, training, and opportunities for participation in policy-making processes.
- **Elimination of Discrimination and Prejudice:** Creating a society free from discrimination and prejudice based on race, gender, age, disability, sexual orientation, etc., through legal protections and social awareness campaigns.
- **Building Social Networks:** In an inclusive society, communities and networks play a critical role in supporting diverse individuals and preventing social isolation, aiming to strengthen social capital.

In this note, we will review our activities from the perspective of social inclusion and discuss our contributions and future developments in this area.

2. Summary of Activities

By utilizing open-source platforms, we have gained access to continuously evolving development environments and communities, allowing us to efficiently procure development resources through standardized and modular software and hardware. For example, one of the most widely-used open-source UAV development environments, "Ardupilot[1]," has opened up not only autopilot but also flight control hardware, making various components accessible worldwide at low cost through international e-commerce sites like Aliexpress. This accessibility has enabled the development of cutting-edge UAVs even in regions with limited infrastructure or financial resources. Additionally, leveraging open-source development forums allows us to swiftly resolve most technical issues with the support of contributors (mostly developers) and contribute to the community by identifying and sharing new challenges. Crucially, these open communities enable proactive problem-solving, even for those without specialized expertise or significant funding.

2.1 STEAM Education Programs for Remote Areas – Open Source UAV Challenges

The use of open-source technology proves highly effective in problem-solving-oriented STEAM programs. By leveraging the advantages of OSUAV (Open Source based UAV), we have provided STEAM education programs focused on drone development even in educational institutions without UAV

specialists[3]. In 2016, we conducted a 3-day, 24-hour intensive workshop on developing anti-poaching surveillance drones for first- and second-year students at a technical university in the mountainous region of Cambodia. Through this workshop, students acquired the know-how to develop fixed-wing drones capable of long-duration flights for monitoring elephant poaching in nearby forests. Over the course of three days, the students were able to solve challenges efficiently by utilizing resources from development communities (forum articles and videos) and deepening their understanding using machine translation in their native language.

Figure 1: short-term intensive workshop on developing anti-poaching surveillance drones utilizing Ardupilot @KIT Cambodia

Additionally, we provided remote and on-site support to the newly established drone department instructors at Japan Aviation Academy (JAA), located in Japan's depopulated mountainous areas, using open-source tools. As a result, they were able to offer a unique educational program for their students to build DIY drones and eventually became collaborators in our drone research and development. Notably, this effort demonstrates how practical, hands-on training could be facilitated using well-prepared open-source resources, even when remote tools like Zoom were insufficient during the pandemic. We built a simple remote work support environment using smartphones, enabling efficient training under constrained conditions. These efforts have contributed to reducing educational disparities and costs through open-source solutions.

Figure2: Remote OSUAV development workshop utilizing a simple collaboration environment where participants can see each other's hands, gaze, work environment, and screen through a smartphone mounted on a headgear.

2.2 Interdisciplinary Problem-Solving Using Open Source UAV

We have undertaken various interdisciplinary projects using Open Source UAVs (OSUAVs). For example, in the "Crowminication Project[6]," we collaborated with Dr. Tsukahara, a biologist, to control crow behavior as part of an effort to coexist with them. This project involved developing custom bird-shaped fixed-wing drones using Ardupilot to mimic the flight patterns of crows.

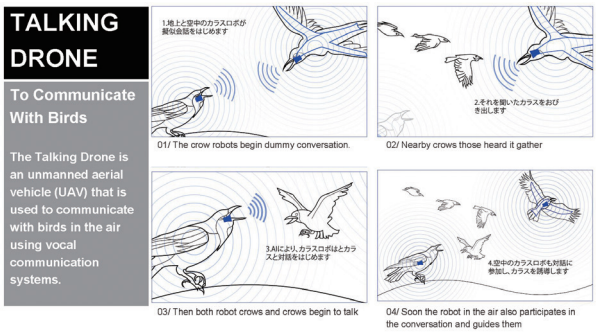

Figure3: Crowmunication concept diagram

Figure4: Prototype of a crow-shaped fixed-wing drone and a crow-guided test

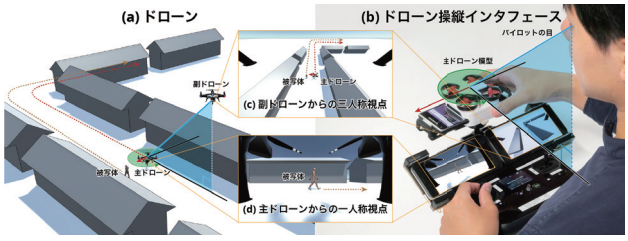

Figure5: Third Person Piloting: a drone piloting and aerial photography interface using two spatially linked camera perspectives.

Another project, "Third Person Piloting[4]," focused on developing a drone piloting and aerial imaging support interface by autonomously controlling multiple camera-equipped drones to enhance situational awareness. Leveraging OSUAV documentation and forums enabled us to conduct trial and error efficiently and facilitated knowledge sharing and development implementation with collaborators who lacked drone expertise. These activities have proven that open source can serve as an effective collaboration tool, allowing researchers from different disciplines to work together smoothly. Additionally, utilizing well-structured open-source communities made it easier for graduate students involved in these projects to work independently, learn, and contribute to the research group.

2.3 Inclusive Sailing Project: Developing Community-Inclusive and Sustainable Mobility Using Open Source UAV Technology

We have supported the research and development of sailing drones in a collaborative international project with EverBlue Technologies. This project, based in locations such as Singapore and Hawaii, brought together America's Cup yacht designers, aerospace engineers, universities, and companies. As advisors on autonomous navigation and user interaction, we participated in the development process by providing drone development courses using Ardupilot to the stakeholders and engineers in the collaboration. By employing OSUAV as a communication tool among engineers, we successfully streamlined remote development work, allowing agile prototyping and feasibility studies for various use cases between Japan and Singapore. This facilitated the smooth development and implementation of sailing drones, including those that automate commercial sailboats.

Figure6: FlyingSailboat developed using Ardupilot (left) and a sailing drone based on a Hansa Class1 sailboat (right).

Figure7: Aiming at Computer Aided Sailing and applying OSUAV to develop a sailboat that assists the sailor. Equipped with automatic/semi-automatic sailing and automatic return functions

Figuere8: OSUAV-applied Computer Aided Sailing experiment where the sailboat can sail autonomously and complement some of the sailor's operations.

This project was implemented as part of the Japanese government's "Smart Island Demonstration Project[5]," testing sustainable mobility on a remote island in Sakata City, Yamagata Prefecture. Local residents and businesses participated, and through experiments using sailing drones, various insights and suggestions were obtained. As a result, the project demonstrated the potential of enhancing sailing accessibility through autopilot rather than full automation and using these technologies as a resource for regional development.

Currently, we are advancing the project "Computer Aided Sailing for Everyone" to achieve inclusive sailing. This project involves co-designing systems that use open-source UAV technology to assist sailors with autopilot, allowing people of all ages and abilities, including those with disabilities, to enjoy sailing. This project aims to explore new ways to make sailing more accessible and enjoyable for everyone.

3. Insights

According to B. Huang's "The Hardware Hacker[2]," open source not only allows copying but also promotes innovation. Hackers use open source to solve problems and create new innovations by combining different open-source components. It is described as a system that "stands on the shoulders of giants," and the diffusion of open-source technology facilitates the creation of new combinations that drive innovation. Joseph Schumpeter, a 20th-century economist, described innovation as "a new combination of existing knowledge," while Clayton Christensen, a Harvard University professor, emphasized "thinking that connects seemingly unrelated things." A notable example is George Soros's distribution of copiers to Eastern European communist states, which spurred democratization movements and led to the emergence of new market economies.

Reviewing our activities in this context, it becomes clear that introducing open source not only fosters inclusive research and development beyond the advantages of local experts and infrastructure but also promotes social participation. From our experience, participants who acquired problem-solving skills through open source tend to take subsequent independent actions (as demonstrated in collaborations with KIT in Cambodia, JAA, and EverBlue Technologies). It is also observed that these participants achieve their goals not by working in isolation but through collaborative efforts with open communities. Additionally, we should note that such research activities, especially those involving hardware development, are supported by digital fabrication technologies such as 3D printing, many of which are open-sourced.

4. Future Direction and Conclusion

In this research note, we reviewed how our approach of utilizing open-source UAV technology has enabled interdisciplinary, international, and inclusive research activities, thereby involving people from various fields and regions regardless of their expertise. Initially, we did not foresee the positive impact of open source; rather, we utilized it to supplement our limited resources and expertise in aerospace-related fields, including UAVs. However, we unexpectedly achieved positive outcomes. By reviewing these activities in line with the " The key characteristics of an inclusive society," we explored the future direction and potential contributions of our activities. With open-source tools and open communities, we have managed to overcome disparities in environments and resources and transcend language and disability barriers to carry out research and development. We are now able to advance an inclusive sailing project using open-source UAV technology, allowing even visually impaired individuals to participate. Within the context of these activities and the recent trend toward inclusive societies, we believe that involving more people will further foster serendipity and new possibilities.

Acknowledgements

Part of this work was carried out under the Cooperative Research Project Program of the Research Institute of Electrical Communication,Tohoku University. The authors would like to thank all the contributors to this project: Kirirom Institute of Technology, Japan Aviation Academy, Tohoku University, and Tokurako Yacht club.

References

[1] ArduPilot - Versatile, Trusted, Open: https://ardupilot.org/. Accessed: 2022-12-20.

[2] Huang, A.B. 2017. The Hardware Hacker: Adventures in Making and Breaking Hardware. No Starch Press.

[3] SUEDA, K. et al. 2021. Open Source-Based UAVs for STEAM Education: Some Case Studies. International Journal of Learning and Teaching. 7, 3 (2021).

[4] Temma, R. et al. 2019. Third-Person Piloting; Increasing Situational Awareness Using a Spatially Coupled Second Drone. Proceedings of the 32Nd Annual ACM Symposium on User Interface Software and Technology (New York, NY, USA, 2019), 507–519.

[5] Ministry of Land, Infrastructure, Transport and Tourism: Smart Island Research Project (スマートアイランドに関する取組) https://www.mlit.go.jp/smartisland/index.html#r_3. Accessed: 2023-04-08.

[6] Sueda, K. et al.: カラスと対話するプロジェクト: カラスにとってのカラスらしさの工学的再現 (Interacting with Crows Project: Engineering reproduction of crow-like characteristics for crows), Proceedings of the Virtual Reality Society of Japan, 23rd Annual Conference (2018), 31E-1.