



AloTwin

Twinning action for spreading excellence in Artificial Intelligence of Things

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REPORT ON THE ALOTWIN SUMMER SCHOOLS

(2)



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Table of Contents

Executive Summary.....	4
1 Introduction	6
2 Second AloTwin Summer School	7
2.1 Programme Summary.....	8
2.2 Summer School Participants.....	12
3 Workshop "Edge AI meets Swarm Intelligence"	13
3.1 Call for papers.....	14
3.2 Topics of interest	14
3.3 Workshop committees	15
4 Summary of the feedback survey	16
5 Conclusion.....	16
APPENDIX 1: Detailed programme of the 2nd AloTwin Summer School.....	18
APPENDIX 2: Keynote talk abstracts	20
APPENDIX 3: Tutorial abstracts.....	21
APPENDIX 4: Hands-on workshop abstracts	22
APPENDIX 6: Results of the feedback survey.....	23
6 List of Figures	30

Executive Summary

The 2nd AloTwin Summer School¹ was organised as a joint event in collaboration with the EU funded SmartEdge project² in the period of September 16-20, 2024. The event took place in Dubrovnik, Croatia, at the Centre for Advanced Academic Studies (CAAS)³ of the University of Zagreb. The AloTwin consortium has organised the program for the first two days of the event (September 16-17) which included invited talks, technical tutorials and hands-on sessions, to offer insightful presentations and discussions on topics relevant to Artificial Intelligence on Things. The third day of the event was dedicated to the technical workshop on “Edge AI meets Swarm Intelligence“ (EAmSI24 workshop⁴), which was organised by researchers from both projects. The workshop program included one keynote talk, nine presentations of selected peer-reviewed papers and a poster session. The primary goal of this workshop was to foster collaboration and the exchange of ideas among researchers and stakeholders interested in topics relevant to Edge AI and Swarm Intelligence. The SmartEdge Summer School program was organised on September 19-20 to include keynote talks, tutorials and hand-on sessions.

Week schedule

- 16-17 September – AloTwin Summer School: Keynote talks, Tutorials, Hands-on sessions
- 18 September – Joint Sessions SmartEdge & AloTwin: Technical Workshop on “Edge AI meets Swarm Intelligence” including a poster session
- 19–20 September – SmartEdge Summer School: Keynote talks, Tutorials, Hands-on sessions

Key highlights of the 2nd AloTwin Summer School (16-18 September) include:

- **Keynotes** by [Aaron Ding \(TU Delft\)](#) on sustainable and trustworthy edge AI for future computing, [Stefan Nastic \(TU Vienna\)](#) on computing paradigms for next-generation computing landscapes, and [Spyros Lalis \(University of Thessaly\)](#) on elevating drones to first-class citizens in the cloud-edge-IoT continuum.
- **Tutorials** on doctoral education at KTH, insights on operating distributed computing continuum systems through active inference, exploring privacy-preserving computation techniques for edge AI, in-network programming and practical guidelines for startups with examples.
- **Hands-on sessions** included two open-source solutions: 1) [AloTwin orchestration middleware](#) enabling edge orchestration of hierarchical Federated Learning workflows and 2) [ColonyOS](#), an event-driven meta-operating system spanning edge and cloud environments.
- Joint technical workshop with the project SmartEdge on “[Edge AI meets Swarm Intelligence](#)”.

The event brought together participants from academia and industry, both renowned experienced researchers and PhD students, to exchange ideas and learn about the latest advances at the intersection of AI, IoT and Edge Computing.

¹ 2nd AloTwin Summer School website: https://aiotwin.eu/aiotwin/activities/2nd_summer_school

² SmartEdge project website, <https://www.smart-edge.eu/>

³ CAAS website, <http://www.caas.unizg.hr/index.html>

⁴ EAmSI24 website <https://www.smart-edge.eu/eamsi24/>

The total number of participants was 42: half of them are PhD students with the largest number of PhD students from UNIZG-FER and TUB, while we can note an increase of interest from external participants compare to the previous edition of the Summer School.

The presentations and extended abstracts of all sessions are available on the project website: https://aiotwin.eu/aiotwin/activities/2nd_summer_school.

1 Introduction

This deliverable presents the report on the second AloTwin Summer School, which took place from 16 to 18 September in Dubrovnik, Croatia, as part of the joint AloTwin and SmartEdge event (dates: September 16-20, 2024; venue: Dubrovnik, Croatia - University of Zagreb - Centre for Advanced Academic Studies (CAAS)). The event was promoted jointly by both projects to increase outreach (Figure 1). The AloTwin consortium was responsible for organising the programme of the first two days (September 16-17) and was involved in organising the joint technical workshop that took place on the third day (September 18). The SmartEdge consortium was responsible to organise the programme on the last two days of the event (September 19-20). In this report, we focus on the first three days of the event, which were under the direct responsibility of the AloTwin consortium.

The main goal of the AloTwin summer schools is to bring together experienced researchers and PhD students interested in IoT, AI and edge computing, and to broaden their knowledge about the latest developments and biggest challenges in these research fields. The programme of the 2nd summer school included four keynote talks, three technical tutorials and two hands-on training sessions tailored to spark participants' interest in the AloT research field. In addition, the AloTwin consortium used the opportunity to present and showcase the orchestration middleware developed as part of the research component of the project. The event also included two skills tutorials: the first tutorial presented the structure and regulations of the doctoral education at KTH, and the second provided initial guidelines on how to setup a startup. Thanks to the collaboration with the SmartEdge project, participants had the opportunity to interact with researchers from industry and explore the technology and use cases developed by the SmartEdge consortium.

The document is organised as follows. Section 2 contains general information about the 2nd AloTwin Summer School, followed by the official programme overview. In Section 3, we present the call for papers and the programme of the technical workshop “Edge AI meets Swarm Intelligence.” An overview of the online feedback survey conducted after the event can be found in Section 4. We conclude the report in Section 5. The detailed programme, the summaries of all presentations and the results of the feedback survey are given in the corresponding appendix sections.

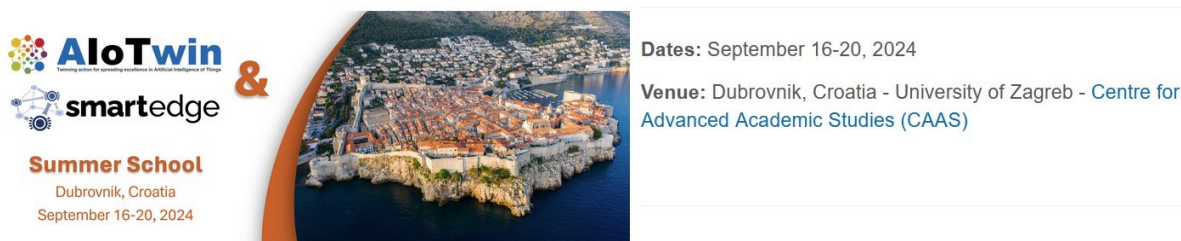


Figure 1. Logo used to promote the joint AloTwin and StartEdge event

2 Second AloTwin Summer School

The 2nd AloTwin Summer School was organised as a joint event in collaboration with the EU funded SmartEdge project in the period of September 16-20, 2024. The event took place in Dubrovnik, Croatia, at the Centre for Advanced Academic Studies (CAAS)⁵ of the University of Zagreb. The two consortia, SmartEdge and AloTwin, share topics of mutual interested on edge and decentralised intelligence in IoT environments, and have a common partner, TUB, with Dr Danh Le Phuoc (TUB) who is the technical coordinator of the SmartEdge project. The SmartEdge project aims to achieve dynamic integration of decentralized edge intelligence while prioritizing reliability, security, privacy, and scalability. It is designing and developing a low-code programming environment which includes the following tools (from <https://www.smart-edge.eu/project/>):

1. **Continuous Semantic Integration (CSI)** – Ensuring interaction with devices through a standardized semantic interface, employing continuous conversion based on declarative mappings scalable from edge to cloud, and enabling a declarative approach to create and orchestrate apps based on swarm intelligence.
2. **Dynamic Swarm Network (DSW)** – Facilitating automatic discovery and dynamic network swarm formation in near real-time, utilizing hardware-accelerated in-network operations for context-aware swarm networking, and embedding network security.
3. **Low-code Toolchain for Edge Intelligence** – Providing semantic-driven multimodal stream fusion for Edge devices, enabling swarm elasticity via Edge-Cloud Interplay, offering adaptive coordination and optimization, and implementing a cross-layer toolchain for the Device-Edge-Cloud Continuum.

The SmartEdge tools will be demonstrated in four application areas: automotive, city, factory, and health, which are also of interest and relevant to the AloTwin use cases and application areas of the AloTwin orchestration middleware. The joint organisation of the event has thus strengthened and diversified the technical content of the joint event, and increased the total number of event participants due to an increased visibility of the joint event (details on the number of participants are given in Section 2.2). In addition, the AloTwin consortium had an opportunity to acquire new knowledge and interact with the prominent academic and industrial partners from the SmartEdge consortium.

The AloTwin consortium has focused on the organisation the program for the first two days of the event (September 16-17) which included three invited talks, five technical tutorials and two hands-on sessions (further details are provided in Section 2.1). The programme has focused on topics relevant to Artificial Intelligence on Things and edge computing.

The third day of the event was dedicated to the technical workshop on “Edge AI meets Swarm Intelligence” (further details are provided in Section 2.2), which was organised jointly by researchers from both projects. The workshop program included one keynote talk, nine presentations of selected peer-reviewed papers and a poster session. The primary goal of this workshop was to foster collaboration and the exchange of ideas among researchers and stakeholders interested in topics relevant to Edge AI and Swarm Intelligence.

⁵ CAAS website, <http://www.caas.unizg.hr/index.html>

The SmartEdge Summer School program was organised on September 19-20, and included two keynote talks and nine tutorials. In this document we focus on reporting the first three days of the event and give an overview of the programme of the SmartEdge Summer School.

2.1 Programme Summary

On the first day of the AIoTwin Summer School, the programme started with an opening ceremony, followed by a keynote speech by **Aaron Ding (TU Delft)** on sustainable and trustworthy edge AI for future computing. **Šarūnas Girdzijauskas (RISE)** gave a talk on the organisation and requirements of doctoral education at KTH Royal Institute of Technology, followed by **Boris Sedlak (TUW)** who presented a tutorial on operating distributed computing continuum systems through active inference. In the afternoon, **Lodovico Giarretta (RISE)** discussed privacy-preserving computation techniques for edge AI. The day concluded with a lecture on the **AIoTwin orchestration middleware** prepared by Ivan Čilić, Ana-Petra Jukić, Katarina Vuknić and Ivana Podnar Žarko from UNIZG-FER, and a hands-on demonstration by Ivan Čilić (UNIZG-FER) of the open-source solution for edge orchestration of hierarchical federated learning workflows developed by researchers from UNIZG-FER and TUW.

The second day began with two keynotes: **Stefan Nastic (TUW)** joined online to present the computing paradigms for the next-generation landscapes of edge environments, and **Spyros Lalis (University of Thessaly)** presented an extensive list of use cases where drones are used as first-class citizens in the cloud-edge-IoT continuum. Afterwards, **Anh Le Tuan and Xuanchi Guo (TUB)** led a tutorial on in-network programming with practical examples of the P4 network programming language. The afternoon included an online skills tutorial on guidelines for startups by **Ivan Voras (Equinox Vision)** and concluded with a hands-on training on **ColonyOS**, an event-driven meta-operating system spanning edge and cloud environments, by **Johan Kristiansson (RISE)**, before the official closing of this part of the AIoTwin Summer School.

On the third day, the technical workshop “Edge AI meets Swarm Intelligence” (<https://www.smart-edge.eu/eamsi24/>) took place, which was jointly organised by two projects, SmartEdge and AIoTwin. The day started with a keynote speech by **Carla Ferreira (NOVA University Lisbon)** on techniques for safe and highly available cloud applications. This was followed by the presentations of nine papers which were reviewed and accepted for publication and presentation in an open access proceedings volume, as well as a poster session which created a lively centre for discussion and exchange of ideas.

On the fourth and fifth day, the SmartEdge project organised two keynote lectures by **Philippe Cudre-Mauroux (University of Fribourg)** and **Trung Kien Tran (Bosch)** as well as a series of tutorials on edge AI and swarm technologies developed for the following use cases: Automotive, Manufacturing and Health.

To summarise, the aims of the summer school were the following:

- Providing participants with a comprehensive understanding of the latest advances in AIoT, edge AI, edge computing for IoT environments, and swarm intelligence.
- Fostering collaboration and networking between academia and industry professionals through interactive sessions.
- Creating the opportunity for researchers and attendees to network, share insights, and explore potential collaborations.
- Equipping participants with practical skills through hands-on training.
- Stimulating further research and development in AIoT-related areas.



Figure 2. Summer school participants during the 1st day of the 2nd AloTwin Summer School

The full programme is available in [APPENDIX 1: Detailed programme of the 2nd AloTwin Summer School](#). Note that on each day of the workshop, we posted a summary of the day on LinkedIn to promote the event to a wider audience and potentially attract interest for future events. Here are the links to the posts:

1. DAY 1, <https://www.linkedin.com/feed/update/urn:li:activity:7241487727706161152>,
2. DAY 2, <https://www.linkedin.com/feed/update/urn:li:activity:7241872198984974336>,
3. DAY 3, <https://www.linkedin.com/feed/update/urn:li:activity:7242460641687486465>.

The following keynote talks were held at the event:

- Keynote by Aaron Ding (TU Delft): Sustainable and trustworthy edge AI for future computing
- Keynote by Stefan Nastic (TUW): Computing paradigms for the next-generation computing landscapes
- Keynote by Spyros Lalis (University of Thessaly): Elevating drones as first-class citizens in the cloud-edge-IoT continuum
- Keynote by Carla Ferreira (NOVA University Lisbon): Techniques for safe and highly available cloud applications

Abstracts of keynote talks are listed in [APPENDIX 2: Keynote talk abstracts](#). Both the abstracts and presentations of the keynote talks in pdf format can be found at https://aiotwin.eu/aiotwin/activities/2nd_summer_school/keynote_talks.



Aaron Ding (TU Delft)



Stefan Nastic (TUW) – held online



Spyros Lalis (University of Thessaly)



Carla Ferreira (NOVA University Lisbon),
introduced by Danh Danh Le Phuoc

Figure 3. Keynote speakers

The list of tutorials is the following:

- Tutorial by Boris Sedlak (TUW): Operating distributed computing continuum systems through active inference
- Tutorial by Lodovico Giaretta (RISE): Privacy-preserving computation techniques for edge AI
- Tutorial by Anh Le Tuan, Xuanchi Guo (TUB): In-Network Programming

Abstracts of all tutorials are listed in APPENDIX 3: Tutorial abstracts. Both the abstracts and presentations of the tutorials in pdf format can be found at

https://aiotwin.eu/aiotwin/activities/2nd_summer_school/tutorials.

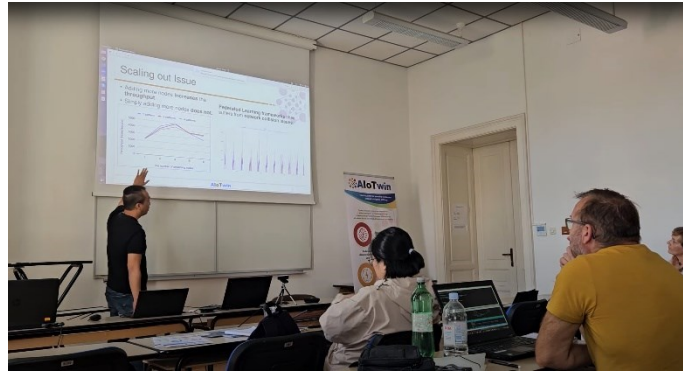


Figure 4. Tutorial sessions

In addition to the keynote talks and tutorials already mentioned, the programme also included two additional tutorials to develop general skills required for a successful completion of the doctoral programme and a fruitful future academic career.

- Tutorial by Sarunas Girdzijauskas (RISE): Doctoral education at KTH
- Tutorial by Ivan Voras (Equinox Vision): Guidelines for startups with examples

Abstracts of the two tutorials for development of skills are available in APPENDIX 3: Tutorial abstracts. Both the abstracts and presentations in pdf format can be found at https://aiotwin.eu/aiotwin/activities/2nd_summer_school/tutorials.



Figure 5. Skill-development tutorials

Finally, the participants had the opportunity to take part in two hands-on sessions.

- Hands-on session by Ivana Podnar Žarko, Ivan Čilić, Ana Petra Jukić, Katarina Vuknić (UNIZG-FER): AloTwin orchestration middleware
- Hands-on session by Johan Kristiansson (RISE): ColonyOS

Abstracts of the two hands-on sessions are available in APPENDIX 4: Hands-on workshop abstracts . Both the abstracts and presentations in pdf format can be found at https://aiotwin.eu/aiotwin/activities/2nd_summer_school/hands-on_workshops.



Figure 6. Hands-on sessions

2.2 Summer School Participants

The event was promoted as a joint event by two projects, with a goal to increase the total number of participants, especially external ones, with many attending the entire event. For organisational reasons, the registration was done separately by two projects: The AloTwin consortium collected the registrations for the first three days of the event, while the SmartEdge consortium conducted the registrations for the last three days of the event and we merged the participant list for the common third day during the workshop. No registration fee was collected from participants; participants covered their own accommodation and travel expenses.

We report the number and distribution of participants per institution separately in two tables: Table 1 for Sept 16-17 and Table 2 for Sept 18.

Table 1. Distribution of participants per institution on Sept 16-17

	UNIZG-FER	RISE	TUW	TUB	External	Total
Top Grade/Senior Researchers	3	2	1	1	3	10
Recognised Researchers	0	1	1	1	1	4
PhD students	7	0	1	2	6	16
Administrators	1	0	0	0	0	1
	11	3	3	4	10	31

Table 2. Distribution of participants per institution on Sept 18

	UNIZG-FER	RISE	TUW	TUB	External	Total
Top Grade/Senior Researchers	3	1	0	1	7	12
Recognised Researchers	0	1	1	1	5	8
PhD students	7	0	1	5	8	21
Administrators	1	0	0	0	0	1
	11	2	2	7	22	42

The total number of participants during the first two days of the event was **31**, including 2 invited speakers, 21 participants from the AtoTwin consortium and 10 external participants (mostly PhD students). We can note one third of the participants is from UNIZG-FER, while the number of external participants is also significant compared to the first edition of the Summer School. External participants are mostly PhD students. The total number of participants during the first two days is lower compared to the total number of participants in the 1st AtoTwin Summer School (36). The reason for this decrease is a slightly lower number of participants from AtoTwin partner institutions RISE and TUW. However, on the third day of the event (workshop), we note a significant increase in the number of participants, bringing the total number of participants to **42**. Half of the participants are, as expected, PhD students, while we can see that the number of participants outside the AtoTwin consortium has increased significantly compared to the first edition of the Summer School. **The organisation of the joint event has thus successfully increased the outreach and visibility of AtoTwin activities and research results outside the AtoTwin consortium.**

3 Workshop "Edge AI meets Swarm Intelligence"

The technical workshop "Edge AI meets Swarm Intelligence" was held on 18 September 2024 in Dubrovnik, Croatia. The call for papers was published on 1 May 2024 and the submission deadline was 29 June 2024. The review process was organised using EasyChair. A total of **15 submissions were received**, and each paper was reviewed by 3 experts from the technical programme committee. Out of the 15 submitted papers, 9 papers were selected for oral presentation in Dubrovnik and inclusion in the workshop proceedings as full papers, while 5 papers were accepted for poster presentation and will be published as short papers. Note that out of the 5 short papers, three were prepared by PhD students from UNIZG-FER and presented as posters during the workshop. Thus, PhD students from UNIZG-FER had the opportunity to discuss and get feedback on their current research ideas and work-in-progress results from the workshop participants. In addition to posters presenting the short papers, external PhD students attending the event also presented their research during the poster session (the total of ~10 posters was presented during the event).

The workshop proceedings will be published as open access CEUR Workshop Proceedings ([CEUR-WS.org](https://ceur-ws.org)).



Figure 7. Workshop participants at CAAS

3.1 Call for papers

Edge AI represents a novel computing paradigm designed to facilitate local data storage and processing, with AI algorithms enabling data treatment directly at the edge of the network. This approach aims to bring intelligence to the end-devices, facilitating real-time decision-making and empowering devices to operate autonomously, reducing reliance on external cloud services.

One of the key topics of interest is to develop low-code programming tool chains or platforms for edge intelligence to enable swarm computing paradigms. The tools will reduce the efforts of building smart systems requiring a collective of heterogeneous devices, sensors, vehicles and robots to collaborate towards a common goal. Such a solution aims at enabling Swarm Intelligence concepts, which are a form of AI that mimics the collective behaviour of decentralised, self-organised systems, like those observed in nature.

Researchers working on the SmartEdge and AloTwin projects share similar research interests in terms of enabling AI at the edge and dealing with the heterogeneity of such environments. Heterogeneity can refer here to differences in network capabilities, processing power, software stacks, APIs, and security protocols across the Cloud-Edge Continuum infrastructure, e.g. continuum reference architecture proposed by the EUCloudEdgeIoT initiative.

3.2 Topics of interest

We welcomed submissions of original research, work-in-progress, and proof of concepts describing original ideas and presenting new directions in edge and swarm AI. We invited submissions related to the design, development, and evaluation of architectures, technologies, and applications for “Edge AI” and “Swarm Intelligence”, including but not limited to:

- Network optimization and interoperable protocols for Edge AI and Swarm Intelligence

- Novel system architectures and hardware designs in Edge AI and Swarm Intelligence
- Network security, data privacy, confidence, and trust in Edge AI and Swarm Intelligence
- AI-enabled resource allocation, federated learning, and swarm intelligence
- Next generation smart use-cases enabled by Edge AI and Swarm Intelligence
- Intelligence in distributed computing continuum systems
- Novel results in embedded AI, in-network computing or heterogeneous computing
- Methods, resources, and experimental findings in autonomous systems

3.3 Workshop committees

Workshop chairs

- Ivana Podnar Zarko (University of Zagreb, Croatia)
- Philippe Cudre-Mauroux (University of Fribourg, Switzerland)
- Trung-Kien Tran (Bosch, Germany)
- Danh Le-Phuoc (TU Berlin, Germany)

Publicity and proceeding chairs

- Ilir Murturi (TU Wien, Austria)
- Anh Le-Tuan (TU Berlin, Germany)

Technical program committee

- Alessio Carenini (CEFRIEL, Italy)
- Mario Scrocca (CEFRIEL, Italy)
- Kari Koskinen (CONVEQS, Finland)
- Mehrdad (CONVEQS, Finland)
- Alan Cueva Mora (DELL, Ireland)
- Christopher Krauß (FHG, Germany)
- Louay Bassbouss (FHG, Germany)
- Philippe Cudre-Mauroux (FRIB, Switzerland)
- Jean-Paul Calbimonte (HESSO – Switzerland)
- Davide Calvaresi (HESSO, Switzerland)
- JJ Vegas Olmos (NVIDIA, Denmark)
- Peng Qian (Oxford University, UK)
- Changgang Zheng (Oxford University, UK)
- Lodovico Giaretta (RISE, Sweden)
- Sarunas Girdzijauskas (RISE, Sweden)
- Kirill Dorofeev (Siemens, Germany)
- Damien Foucard (TU Berlin, Germany)
- Mario Kušek (University of Zagreb, Croatia)
- Gordan Ježić (University of Zagreb, Croatia)
- Marie-Claire Fogue (W3C/ERCIM)
- Michalis Mountantonakis (W3C/ERCIM)
- Panagiotis Papadacos (W3C/ERCIM)
- Filippo Cugini (CNIT, Italy)
- Michelangelo Guaitolini (CNIT, Italy)

The primary goal of this workshop was to foster collaboration and the exchange of ideas among researchers and stakeholders. The workshop provided a platform for participants to share their experiences, best practices, case studies, and to identify emerging research areas and potential solutions to existing challenges.

4 Summary of the feedback survey

A feedback survey was carried out after the event and was completed by eight participants. The number of responses was a bit low, but nevertheless informative. We formulated 21 questions and asked for recommendations to help us improve future events.

It is interesting to note that participants rated their satisfaction with the event as 4.88 overall. 5 of the 8 participants stated that overall the summer school exceeded their expectations, while the remaining 3 stated that it met their expectations.

The content of the workshop was predominantly rated as very clear and useful. The keynote presentations were rated as either excellent (63%) or very good (37%). All participants felt that the tutorials were both informative and interesting. For hands-on sessions, all participants indicated that they were (very) effective in acquiring new skills. Also, all participants indicated that the balance between technical and skill sessions was just right (100%) and that there were plenty of networking opportunities (88%). Six (6) participants stated that had a great time during the social event and would love to have more social events during the summer school. These are the points to consider when planning the social events for the next edition of the summer school.

In terms of the organisation of the joint technical workshop with the SmartEdge project on “Edge AI meets Swarm Intelligence”, the overall quality of the workshop was predominantly rated as excellent (6) and good by two (2) participants. Almost all participants stated that time allocated for each presentation was sufficient, and all of them indicated that the poster session was well-organised, and the allocated time for discussion was just right. The participants stated that the comments received during the poster session were valuable and constructive. Also, all participants said they would consider participating in a similar workshop in the future. They would also be most likely to recommend the event to a friend or colleague.

The sessions and topics that were rated as the most valuable are as follows: IoT cybersecurity and AI; the keynote with drones; Accelerating Data Processing through Hardware/Software Co-Design in SmartEdge.

All participants stated that they were very happy with the logistics and organisation overall, while the quality of the food could be improved. Most of the surveyed participants were also very happy with the venue and found the accommodation excellent or good in terms of comfort and convenience. One participant left an additional comment regarding the Summer School: “Great organization team, excellent production!”.

All results of the feedback survey are included in APPENDIX 6: Results of the feedback survey.

5 Conclusion

This deliverable reports on the programme and outcomes of the second AloTwin Summer School which was organised as a joint event by two Horizon Europe projects: AloTwin and SmartEdge. Researchers

working on the two projects share similar research interests on enabling AI at the edge in IoT use case scenarios and dealing with the heterogeneity of such environments. The event brought together experienced researchers both from academia and industry, and PhD students from all AIoTwin partner institutions and other European universities. Half of the event participants were PhD students, and we have successfully increase the number of PhD students participating in the event who are outside the AIoTwin consortium. The event has fostered a lively exchange of knowledge, discussion of open challenges in AIoT and edge AI, and facilitated interactions with researchers from other institutions. All PhD students received a certificate of participation indicating the equivalent of ECTS credits for their participation and engagement in the specific summer school activities.

To summarize the impressions after the event, we can conclude that the targeted objectives were successfully met, including:

- Providing participants with a comprehensive review of the latest advances in the following fields: AIoT, edge AI and swarm intelligence.
- Promoting collaboration and networking between participants as well as opening up additional opportunities for collaboration.
- Increasing the outreach and visibility of AIoTwin activities and research results outside the AIoTwin consortium.

The AIoTwin Summer School was a successful event that provided a valuable opportunity for participants to network with other experts in the field and to be inspired to pursue careers in AIoT and edge computing research and development. The Summer School also helped to raise awareness about the AIoTwin project and its goals, and attached a significant number of participants outside of the AIoTwin consortium.

APPENDIX 1: Detailed programme of the 2nd AloTwin Summer School

Monday, September 16th 2024

09:00 – 09:15	Opening Ceremony
09:15 – 10:30	Keynote talk 1 Aaron Ding (TU Delft): Sustainable and trustworthy edge AI for future computing
10:30 – 11:00	Tutorial 1 Sarunas Girdzijauskas (RISE): Doctoral education at KTH
11:00 – 11:30	Coffee break
11:30 – 12:30	Tutorial 2 Boris Sedlak (TUW): Operating distributed computing continuum systems through active inference
12:30 – 14:00	Lunch break
14:00 – 15:00	Tutorial 3 Lodovico Giaretta (RISE): Privacy-preserving computation techniques for edge AI
15:00 – 15:30	Coffee break
15:30 – 17:00	Hands-on-training 1 Ivana Podnar Žarko, Ivan Čilić, Ana Petra Jukić, Katarina Vuknić (UNIZG-FER): AloTwin orchestration middleware

Tuesday, September 17th 2024

09:00 – 10:00	Keynote 2 Stefan Nastic (TUW): Computing paradigms for the next-generation computing landscapes
10:00 – 11:00	Keynote 3 Spyros Lalis (University of Thessaly): Elevating drones as first-class citizens in the cloud-edge-IoT continuum
11:00 – 11:30	Coffee break
11:30 – 12:30	Tutorial 4 Anh Le Tuan and Xuanchi Guo (TUB): In-Network Programming
12:30 – 14:00	Lunch break
14:00 – 15:00	Tutorial 5 Ivan Voras (Equinox Vision): Guidelines for startups with examples
15:00 – 15:30	Coffee break

15:30 – 17:00	Hands-on-training 2 Johan Kristiansson (RISE): ColonyOS
	Closing of the AloTwin Summer School

Wednesday, September 18th 2024

“Edge AI meets Swarm Intelligence” technical workshop

08:30 – 08:50	Morning coffee
08:50 – 09:00	Opening ceremony
09:00 – 10:30	“Techniques for safe and highly available cloud applications” Keynote by Carla Ferreira (TarDIS)
10:30 – 11:00	Coffee break + poster session
11:00 – 11:30	Paper: Swarm Intelligence for Green Data Orchestration – A Vision for Energy-Efficient Computing in the Edge Continuum Authors: Aidan O Mahony, Fred Buining, Péter Forgács and Melanie Schranz
11:30 – 12:00	Paper: Performance Evaluation of ROS2-DDS middleware implementations facilitating Cooperative Driving in Autonomous Vehicle Authors: Sumit Paul, Danh Le-Phuoc and Manfred Hauswirth
12:00 – 12:30	Paper: Experimental comparison of graph-based approximate nearest neighbor search algorithms on edge devices Authors: Ali Ganbarov, Jicheng Yuan, Anh Le-Tuan, Manfred Hauswirth and Danh Le-Phuoc
12:30 – 14:00	Lunch break + poster session
14:00 – 14:30	Paper: Not All RDF is Created Equal: Investigating RDF Load Times on Resource-Constrained Devices Authors: Piotr Sowiński, Anh Le-Tuan, Paweł Szymeja and Maria Ganzha
14:30 – 15:00	Paper: Dynamic Knowledge Graph Based Swarm Networks Authors: Xuanchi Guo, Anh Le-Tuan and Danh Le Phuoc
15:00 – 15:20	Coffee break + poster session
15:20 – 15:50	Paper: Cost-Effective and Efficient Scene Understanding for Traffic Cameras Authors: Thuy-Duong Tran and Trung-Kien Tran
15:50 – 16:20	Paper: Co-Learning: Towards Semi-Supervised Object Detection with Road-side Cameras Authors: Jicheng Yuan, Anh Le-Tuan, Ali Ganbarov, Manfred Hauswirth and Danh Le-Phuoc
16:20 – 16:40	Coffee break + poster session

16:40 – 17:10	<p>Paper: Towards Complete Input Representations for Vehicle Trajectory Prediction Models</p> <p>Authors: Marcel Milich, Trung-Kien Tran and Maximilian Naumann</p>
17:10 – 17:40	<p>Paper: A comparison of extended object tracking with multi-modal sensors in indoor environment</p> <p>Authors: Jiangtao Shuai, Martin Baerveldt, Manh Nguyen-Duc, Anh Le-Tuan, Manfred Hauswirth and Danh Le-Phuoc</p>
17:40 – 18:00	Closing the workshop
19:30	<p>Social event – Workshop Dinner</p> <p>Restaurant Marangun Food & Bar</p> <p>Address: street Iva Vojnovića 7a, 20000, Dubrovnik</p> <p>Web: https://marangun-restaurant.com/</p>

APPENDIX 2: Keynote talk abstracts

Aaron Ding: Sustainable and trustworthy edge AI for future computing

Similar to the progression from cloud computing to cloud intelligence, we are witnessing a fast evolution from edge computing to edge intelligence (aka Edge AI). As a rising research branch that merges distributed computing, data analytics, embedded and distributed ML, Edge AI is envisioned to provide adaptation for data-driven applications and enable the creation, optimization and deployment of distributed AI/ML pipelines. However, despite all the promises ahead, the path to realize Edge AI is far from straightforward. This keynote will illustrate a major concern of Edge AI from the trustworthy and sustainable perspectives, because critical building blocks are still missing. On top of practical lessons from my latest EU H2020 SPATIAL and Marie Curie APROPOS projects, the keynote will share an envisioned roadmap, serving as a steppingstone on which the promise of Edge AI can be established for future computing.

Stefan Nastic: Computing paradigms for the next-generation computing landscapes

Serverless computing has established itself as a compelling paradigm for developing modern cloud- and edge-native applications. Serverless represents the next step in the evolution of cloud programming models, services, and platforms, which is especially appealing due to its low management overhead, easy deployment, scale-to-zero, and promise of optimized costs. In this talk, we take a closer look at the state of serverless computing, particularly focusing on the opportunities and challenges related to building Serverless applications and systems in the edge-cloud continuum. We also present our latest work in the Polaris project, which is an open-source project hosted by Linux Foundation, that has been developing various state-of-the-art serverless approaches for the 3D computing continuum.

Spyros Lalis: Elevating drones as first-class citizens in the cloud-edge-IoT continuum

The paradigm of edge computing has gained significant traction, advocating the movement of data transfers and data processing tasks close to the data sources in order to reduce Internet and cloud traffic, avoid performance bottlenecks, reduce latencies and minimize privacy issues. Typical data producing

devices are embedded sensors in homes and factories, street cameras, mobile phones or even (self-driving) cars. A more recent addition to the list of data producers are aerial unmanned vehicles (drones), which can be used to provide focused aerial sensing thereby complementing any ground-based sensors. However, drones currently need to be controlled by a human pilot, even if this can be done using high-level commands thanks to advanced onboard autopilot technology. They also typically run preinstalled software customized for specific tasks. This considerably limits deployment and reduces flexibility. Instead, drones can be viewed as an inherent part of the system infrastructure, like temperature, pollution or camera sensors deployed in an area of interest, becoming a shared resource that can be engaged on demand in a flexible and dynamic way by one or more applications. The talk will discuss some of the challenges that must be addressed to achieve this vision and will present work that was done to integrate drones in the cloud-edge-IoT continuum.

Carla Ferreira: *Techniques for safe and highly available cloud applications*

Building trustworthy cloud applications is inherently complex and error-prone, and requires developers with a high level of expertise. In this talk, I will discuss techniques that leverage theoretical advances to safely reduce or even avoid altogether coordinating the execution of operations. The approach consists of modifying operations in a way that application invariants are ensured to be always maintained. When no conflicting updates occur, the modified operations present their original semantics. Otherwise, it uses sensible and deterministic conflict resolution policies that preserve the invariants of the application. Conflict resolution policies are built into the TaRDIS toolbox which uses an event-based programming model and verification framework. TaRDIS is a Horizon Europe project which focuses on supporting the correct and efficient development of applications for swarms and decentralised distributed systems with a primary goal to significantly ease the complexity and reduce the effort of building correct and efficient heterogeneous swarms.

APPENDIX 3: Tutorial abstracts

Sarunas Girdzijauskas: *Doctoral education at KTH*

This presentation offers a comprehensive overview of doctoral education at KTH. It begins with a brief history and general information about KTH, followed by an outline of doctoral degree objectives in Sweden. Key topics include the Individual Study Plan (ISP), and course requirements, with emphasis on mandatory general skills courses. The thesis process and defense protocol, including the roles of the opponent and PhD committee, are also covered. Additionally, the talk addresses the Student-Supervisor Expectation Form and KTH's Quality Management System, ensuring academic quality and guidance.

Boris Sedlak: *Operating distributed computing continuum systems through active inference*

Distributed computing continuum systems combine various computational layers into one cohesive platform. Thus, clients can benefit both from low-latency computations, i.e., from Edge devices, as well as highly available and virtually unlimited resources, i.e., from the Cloud. Nevertheless, as components become more distributed over a computing architecture, enforcing requirements (e.g., low latency or energy consumption) becomes equally challenging. To that extent, we propose causal mechanisms that identify how computing services can ensure their internal requirements, as well as how they impact other components through their actions. We empirically train these probabilistic models through a neuroscience framework -- Active Inference -- that promises quick convergence and verifiable behaviour.

Lodovico Giarretta: *Privacy-preserving computation techniques for edge AI*

In this tutorial, we look at the different ways in which private training data can be leaked from edge devices that are collaboratively building an AI model, either during distributed training (e.g. Federated Learning) or during inference. We then review four techniques that can be deployed to prevent these data leaks: secure multi-party computation, fully-homomorphic encryption, trusted execution environments, and differential privacy. We look at how these different techniques, each developed for a separate, non-AI use-case, can be employed to secure distributed learning at the edge, and we evaluate their pros and cons.

Anh Le Tuan, Xuanchi Guo: *In-Network Programming*

This short tutorial on the data plane programming language P4 begins with an introduction to the core concepts of Software-Defined Networking (SDN), emphasizing how P4 was designed to improve the flexibility of data plane programming for SDN. The tutorial highlights P4's three main properties, shows example architectures and targets, and provides an overview of P4's programmable pipeline using the V1 model. The speaker also discusses several state-of-the-art research works related to P4. Basic P4 concepts such as primitive types, header formats, parsers, match-action tables, P4 controls, and deparsers are introduced, each accompanied by an example. The session concludes with a hands-on coding exercise where participants implement layer 3 destination-based IPv4 forwarding using P4, followed by an exercise showcasing P4's computing functionality. These tasks are conducted in a Mininet environment using Docker, allowing attendees to run experiments directly on their laptops.

Ivan Voras: *Guidelines for startups with examples*

This tutorial explores the essential steps and challenges of founding a startup. It begins by considering potential locations, while recognizing that Europe may be less startup-friendly than the US. The tutorial defines what a startup is, explaining its goals and outlining key phases: from the initial idea and proof of concept to the development of a Minimum Viable Product (MVP), followed by the beta version and Version 1.0. Financial aspects are discussed, with practical advice on how to find investors, while the significance of effective marketing strategies is highlighted.

APPENDIX 4: Hands-on workshop abstracts

Ivan Čilić, Ana Petra Jukić, Katarina Vuknić, Ivana Podnar Žarko: *AloTwin orchestration middleware*

The hands-on workshop presented the open-source solution named the AloTwin orchestration middleware which enables edge orchestration of hierarchical Federated Learning workflows. It is being developed in collaboration by researchers from UNIZG-FER and TU Vienna within the research component of the AloTwin project.

Johan Kristiansson: *ColonyOS*

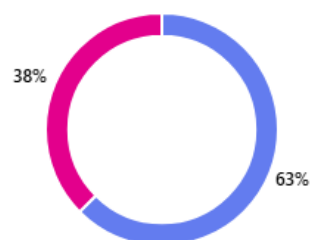
This tutorial introduced ColonyOS, an open-source Meta-Operating System designed to seamlessly manage computational workloads across heterogeneous platforms, including HPC, cloud, and edge environments. Participants were guided through the key features and architecture of ColonyOS, showcasing its ability to orchestrate distributed systems for efficient workload management. Attendees

learned how to install and configure ColonyOS, followed by hands-on demonstrations of several practical examples.

APPENDIX 6: Results of the feedback survey

1. Did the Summer School content meet your expectations?

- Beyond my expectations 5
- Met as expected 3
- Below my expectations 0



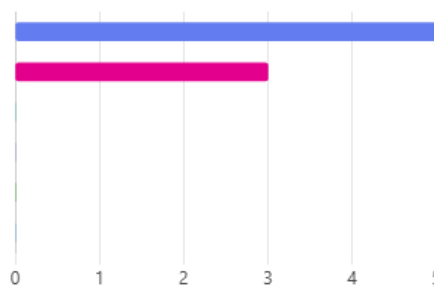
2. How did you find the following aspects of the event?

- Not Applicable
- Not Clear and Useful
- Somewhat Clear and Useful
- Clear and Useful
- Very Clear and Useful

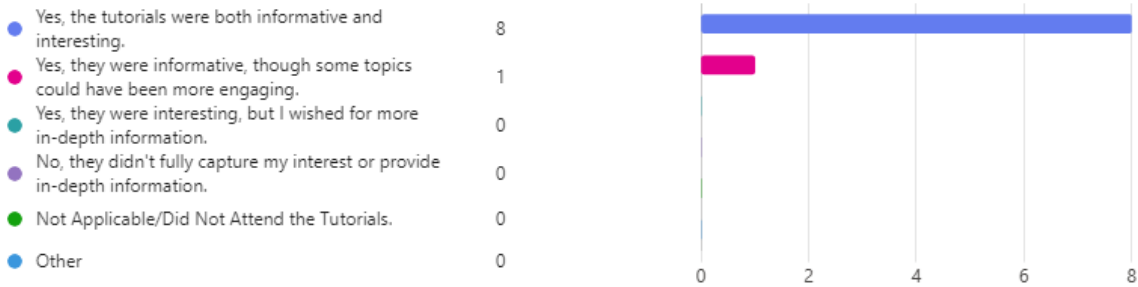


3. Rate the **keynote lectures** in terms of their quality and relevance (for additional comments, please write in "Other").

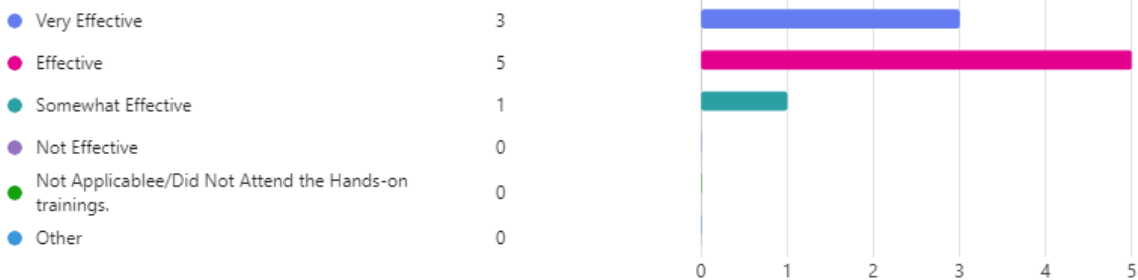
- Excellent 5
- Very good 3
- Fair 0
- Poor 0
- Not Applicable/Did Not Attend the keynote lectures. 0
- Other 0



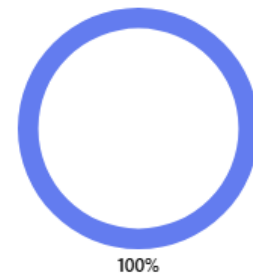
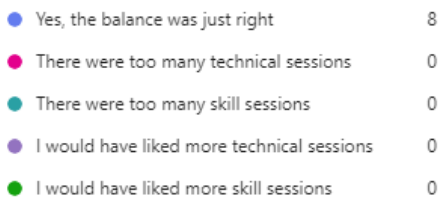
4. Did you find the **tutorials** both informative, offering interesting topics, and effective in expanding your knowledge? *(for additional comments, please write in "Other")*



5. Rate the **hands-on trainings** in terms of their effectiveness in helping you acquire new skills *(for additional comments, please write in "Other")*.

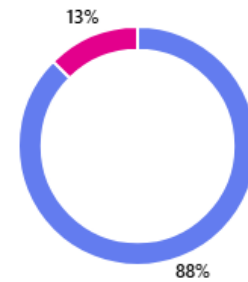


6. Balance Between Technical and Skill Sessions



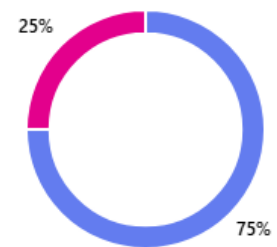
7. Networking Opportunities

● Yes, plenty of opportunities for networking.	7
● Yes, but there could have been more networking opportunities.	1
● Neutral - I neither had too many nor too few networking opportunities.	0
● No, I would have liked more chances to network.	0
● No, there were very limited networking opportunities.	0



8. How did you find the social event (*workshop dinner*) in terms of networking and overall experience?

● Excellent; I had a great time and would love to have more social events during the summer school.	6
● Good; I found it enjoyable, and I believe one social event during the summer school is sufficient.	2
● Fair; it was nice, but I didn't find it very valuable for networking.	0
● I did not attend the event.	0
● Other	0



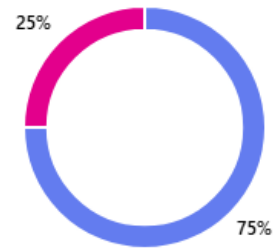
9. How satisfied are you with the overall logistics and organization of the Summer School (e.g., registration, schedule, communication)?

● Very unhappy ● Somewhat unhappy ● Neither happy nor unhappy ● Somewhat happy ● Very happy



10. How would you rate the overall quality of the "Edge AI meets Swarm Intelligence" workshop?

● Excellent	6
● Good	2
● Average	0
● Poor	0



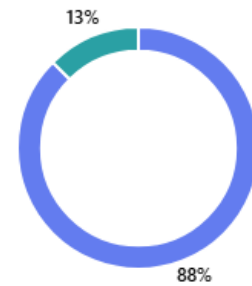
11. Did you find the structure of the workshop (**presentations and poster session**) clear and organized? If not, do you have any suggestions or comments for improvement?

4
Responses

Latest Responses
"yes"
...

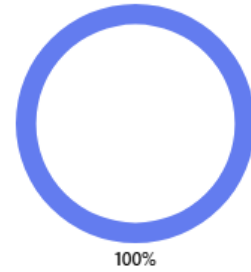
12. Do you think the time allocated for each presentation was sufficient?

● Yes, it was sufficient.	7
● Somewhat, but presenters needed more time.	0
● Somewhat, but the presentations were too long.	1
● No, the time allocation was inadequate.	0
● Other	0



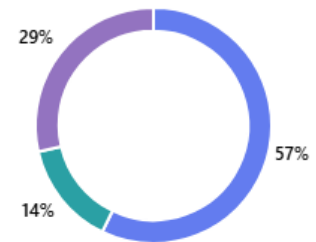
13. Do you think the time allocated for poster session was sufficient?

- The poster session was well-organized, and the time was just right. 8
- Somewhat, but I believe a bit more time would have been helpful, and it should avoid coffee break... 0
- No, the time allocated was insufficient for effective discussion. 0
- I did not participate in the poster session. 0
- Other 0



14. For paper authors: Were the reviews and comments provided during the workshop valuable and constructive?

- Yes, the comments and reviewers were valuable and constructive. 4
- No, the comments and reviewers did not meet my expectations. 0
- Not Applicable/I did not receive comments or interact with reviewers. 1
- Other 2

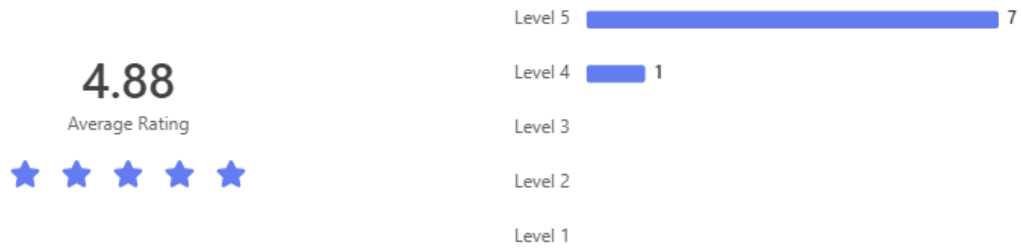


15. Would you be interested in attending a similar workshop in the future?

- Yes 8
- No 0
- Maybe 0



16. Overall, how satisfied are you with the event?



17. How would you rate the accommodation at CAAS in terms of comfort and convenience?



18. Which specific session topics did you find the most valuable or interesting?

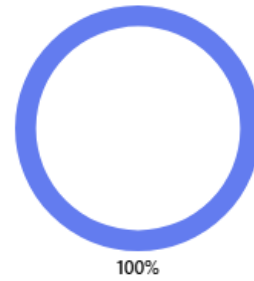


19. How likely are you to recommend the event to a friend or colleague?



20. Would you consider participating in future AIOTWIN Summer School events?

- Yes 8
- No 0
- Maybe 0



21. If you have any particular recommendations to enhance the upcoming AIOTWIN Summer School events, kindly provide them here. Additionally, please don't hesitate to share any extra comments, suggestions, or feedback you may have regarding the Summer School.

1
Responses

Latest Responses
...

6 List of Figures

Figure 1. Logo used to promote the joint AloTwin and StartEdge event	6
Figure 2. Summer school participants during the 1 st day of the 2 nd AloTwin Summer School.....	9
Figure 3. Keynote speakers	10
Figure 4. Tutorial sessions.....	11
Figure 5. Skill-development tutorials.....	11
Figure 6. Hands-on sessions.....	12
Figure 7. Workshop participants at CAAS	14