Project partners

Project Owner

Project Owner	
Institution / company (Norwegian name)	FORZASYS AS
Address	Postboks 134
Postal code	1325
City	LYSAKER
Country	Norway
E-mail	paalh@forzasys.com
Website	
Enterprise number	913968026
Is the Project Owner for this project defined as an undertaking according to the state aid rules?	Yes
Size of the enterprise	Small
Is the Project Owner part of the same business concern as any of the partners?	No
Partner's role	Both research activity and financing

Project administrator

First name	Pål
Last name	Halvorsen
Date of birth	261271
National identity number	*****
Gender	Male
Position/title	CEO
Phone	97080007

E-mail	paalh@forzasys.com
Confirmation	✓ The application has been approved by the Project Owner

Project manager

First name	Pål
Last name	Halvorsen
Date of birth	261271
National identity number	*****
Gender	Male
Institution / company (Norwegian name)	FORZASYS AS
Address	Postboks 134
Postal code	1325
City	LYSAKER
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Position/title	CEO
Academic degree	Dr. Scient
Preferred language	English
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Collaborating partners and R&D-suppliers

1

Institution/ company	SIMULA METROPOLITAN CENTER FOR DIGITAL ENGINEERING AS
Address	C/O Simula Research LaboratoryPostboks 134
Postal code	1325
City	LYSAKER
Country	Norway
Enterprise number	920203612
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Application number: ES687470 - Project number: 327717 - IPNÆRINGSLIV21
Innovation Project Innovation Project for the Industrial Sector
AI-PRODUCER: AI-based Video Clipping and Summarization of Sport Events

Contact tel.	90018483
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Partner's role	Only research activity
Is the partner for this project defined as an undertaking according to the state aid rules?	No

Project info

Project title

Project title	AI-PRODUCER: AI-based Video Clipping and Summarization of Sport Events

Primary and secondary objectives of the project

Targeting the costly video broadcast and streaming service productions, the primary objective of the AI-PRODUCER project is to provide a new AI-component automating some of the manual, tedious, costly, and error prone work. Using AI to analyse the video and metadata, we are making the event and highlights production easier and more efficient by providing accurate clipping (event start and stop positions in the video), adding metadata and creating summaries, i.e., greatly reducing cost and manual labor, and improving the user experience due to automated and better productions.

Secondary objectives include:
1. Research and develop an end-to-end automated clipping and metadata enhancement solution.
2. Extend the clipping and annotation system to automatically generate game summaries and highlights.
3. Real-world assessment and validation of the system comparing the system output to human annotators and producers.

Project summary

Video productions are part of an enormous industry where soccer alone has a market share of about 45% of the $500 billion global sports industry. There is a huge interest in sport event and summary consumption for both broadcasted and streamed on the web. A lot of resources are put into producing the content in an efficient and high-quality manner.

However, generating such summaries and events requires expensive equipment, includes a lot of tedious expensive manual labor, and the operation is often performed redundantly by different actors for different purposes. Forzasys has already developed an improved annotation and production system optimising the manual procedures and reducing the need for expensive equipment. In this project, we are targeting an AI-based solution assisting the current production personnel in their daily work and extending the current system, i.e., allowing a production of highlights at a higher pace and enriched with additional metadata. Building on our experience in sport analysis, sport video delivery systems, and use of AI for video and image analysis in both sport and medicine, the idea is to use AI to analyse the video from the area around a detected event, using for example scene change detection, logo identifications, audio analysis, change of cameras, game transitions and replay recognition, i.e., all information to be

used to enable an accurate automated AI-based clipping operation. Furthermore, other enhancement methods will also be investigated, like adding more detailed text descriptions, tags and appropriate thumbnail selection describing the events. Moreover, targeting the labour expensive generation of highlights after the game, and even in the half-time break, we also aim for AI-automated solutions for collecting the most relevant events and combining and clipping these into a highlight summary package to be used by various actors like the league streaming services, media and TV broadcasters.

Outcomes and impacts

The project outcome is expected to be a complete AI-producer solution usable for both live and offline import operations, and should support generation of accurate video-clips of events matching different requirements concurrently. Moreover, the system should be able to produce highlights summaries of a game, combining relevant events into one video, based on rules and priorities given by the customer, and a given time budget.

The proposed solutions can have a large impact in an area where there are mainly tedious manual operations carefully annotating, clipping and describing every single event in a sport happening. For example, given the high number of soccer games, a lot of manual man power, imposing for example large costs and long delays, can be reduced. For the top leagues in Scandinavia only, we are estimating cost savings in the order for 300-400KNOK per year per league. The AI-producer can easily be expanded to all kind of events all over the world.

Placement

Funding scheme - supplementary info from applicant

Programme / activity	IPNÆRINGSLIV21
Application type	Innovation Project

Topic

Thematic Area	Topic
Industry and services	ICT industry
Industry and services	Media and culture

Classification of scientific disciplines

Filter by subject field	Filter by subject	Discipline
Teknologi	Informasjons- og kommunikasjonsteknologi	Datateknologi

Other relevant programmes/ activities/projects	
If applying for additional funding, specify project number	
Is this proposal related to other	

grant applications or ongoing projects allocated support from the Research Council and/or any other public funding scheme?	No

Progress plan

Project period

From date (dd.mm.yyyy)	01.07.2021
To date (dd.mm.yyyy)	31.12.2022

Main activities and milestones in the project period (year and quarter)

	Milestones throughout the project	Main activity / Category	From	Quarter	To	Quarter
1	T1.1 - data collection	Industrial research	2021	3	2021	4
2	T1.2 - specification	Industrial research	2021	3	2021	3
3	Finished dataset	Milestone	2021	4	2021	4
4	T2.1 - clipping sota review	Industrial research	2021	3	2021	3
5	T2.2 - clipping algoritms	Industrial research	2021	3	2022	3
6	First clipping algorithm and pipeline	Milestone	2022	1	2022	1
7	Usable clipping pipeline implemented	Milestone	2022	2	2022	2
8	T2.3 - clipping algorithms evaluation	Industrial research	2022	1	2022	3
9	T2.4 - clipping pipeline implementation	Experimental development	2022	2	2022	3
10	T3.1 - summarisation SOTA review	Industrial research	2022	1	2022	1
11	T3.2 - summarisation algorithms	Industrial research	2022	1	2022	3
12	First summarization model and pipeline implem	Milestone	2022	2	2022	2
13	Usable summarisation pipeline implemented	Milestone	2022	3	2022	3
14	T3.3 - summarisation algorithm evaluation	Industrial research	2022	2	2022	3
15	T3.4 - summarisation pipeline implemented	Experimental development	2022	3	2022	3
16	Full end-to-end prototype developed	Milestone	2022	4	2022	4
17	T4.1 - final system evaluation	Industrial research	2022	4	2022	4
18	Assessment finished	Milestone	2022	4	2022	4

Budget

Costs per project partner per main activity (NOK 1000)

The heading of the table displays the activity numbers for main activities as these are listed in the Progress plan (when they have been entered). The selected category appears in parentheses.

	1 (IF)	2 (IF)	4 (IF)	5 (IF)	8 (IF)	9 (EU)	10 (IF)	11 (IF)	14 (IF)
FORZASYS AS	350	50	150	1630	450	300	100	1040	350
SIMULA METROPOLITAN CENTER FOR DIGITAL ENGINEERING AS	0	0	30	142	70	0	30	65	30
Totals	350	50	180	1772	520	300	130	1105	380

	15 (EU)	17 (IF)	Sum
FORZASYS AS	300	200	4920
SIMULA METROPOLITAN CENTER FOR DIGITAL ENGINEERING AS	0	0	367
Totals	300	200	5287

Cost plan (NOK 1000)

	2021	2022	2023	2024	2025	2026	2027	2028	Sum
Payroll and indirect expenses	1620	3240							4860
Procurement of R&D services	122	245							367
Equipment	10	20							30
Other operating expenses	10	20							30
Totals	1762	3525	0	0	0	0	0	0	5287

Specification

Payroll - Forzasys:
2 persons fulltime (assuming 1800 hours) using an anticipated cost of about 0,1% of the yearly salary as hourly cost.

Procurement - SimulaMet:
Assuming about half a day in average per week (will vary). Using SimulaMet's approved rates for RCN.

Equipment:
AWS cloud costs running the needed servers and machines. Own machines are assumed to exist and covered as in-kind.

Other expenses:
Open access publishing, assuming about 10 KNOK per paper, and one paper per 6 months.

The equipment and other costs are placed under the algorithm research tasks (T2.2 and T3.2)

Application number: ES687470 - Project number: 327717 - IPNÆRINGSLIV21
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Cost code (NOK 1000)

	2021	2022	2023	2024	2025	2026	2027	2028	Sum
Trade and industry	1640	3280							4920
Research institutes	122	245							367
Universities and university colleges									0
Other sectors									0
Abroad									0
Totals	1762	3525	0	0	0	0	0	0	5287

Funding by project partner (NOK 1000)

	The Research Council	Own financing	Other funding	Sum	Specification of other funding
FORZASYS AS	3816	1471	0	5287	
Totalsum	3816	1471	0	5287	

Funding plan (NOK 1000)

	2021	2022	2023	2024	2025	2026	2027	2028	Sum
Own financing	440	1031							1471
International funding									0
Public funding									0
Private funding									0
The Research Council	1322	2494							3816
Totals	1762	3525	0	0	0	0	0	0	5287

Specification

2021:
All activities in 2021 (the first 6 months are assumed to be industrial research), this we have planned with 75% support from RCN.

2022:
The more implementation heavy tasks (T2.4 and T3.4) are assumed be development research. For these, we have sought 50% support. The other industrial research tasks are issued supported 75%.

Attachments

Project description

Project description	ES687470_001_2_Prosjektbeskrivelse_20210413

Reference	2021_NFR_InnovationProject_AI_producer-5.pdf

Curriculum vitae (CV)

Curriculum vitae (CV)	ES687470_002_1_CV_20210412
Reference	CV-PH-ipn-template-for-cv-2021-AI-producer.pdf

Curriculum vitae (CV)	ES687470_002_4_CV_20210412
Reference	CV-TK-ipn-template-for-cv-2021-AI-producer.pdf

Curriculum vitae (CV)	ES687470_002_6_CV_20210412
Reference	CV-MAR-ipn-template-for-cv-2021-AI-producer.pdf

Partner information

Partner information	ES687470_017_1_Bedriftsopplysninger_20210412
Reference	Microsoft Word - ipn-information-about-applicant-Forzasys-2021.docx.pdf

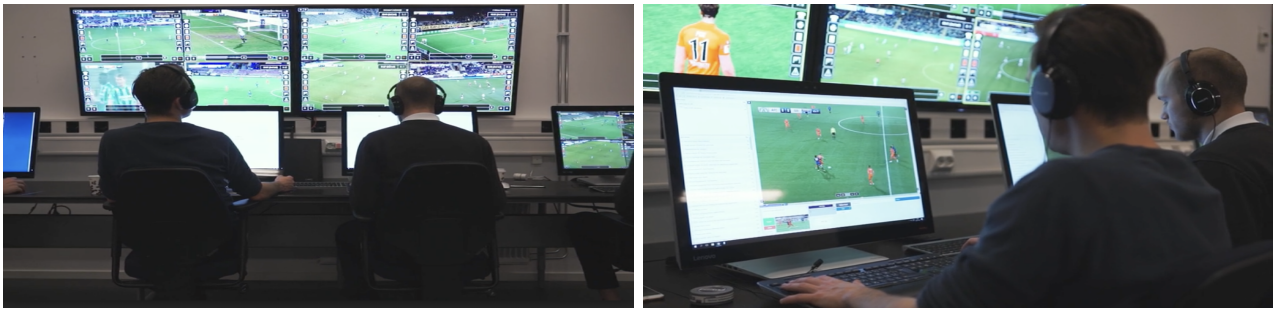
Partner information	ES687470_017_2_Bedriftsopplysninger_20210412
Reference	Microsoft Word - ipn-information-about-applicant-SIMULAMET-2021.docx.pdf

AI-PRODUCER:
AI-based Video Clipping and Summarization of Sport Events

PART 1: The planned innovation

1 Underlying idea

Across different sports disciplines, soccer has a market share of about 45% of the $500 billion global sports industry[1]. The amount of content world-wide is enormous and rapidly growing, and there is a huge interest from various actors to consume the available data. In this respect, as already done for decades, it is important to provide summaries of games, and more recently, provide streams of single events such as goals, cards, saves and penalties. However, generating such summaries and events requires expensive equipment. In addition, a lot of tedious, expensive, manual labor is needed for detecting events, clipping the events and producing a summarization of a combination of events. This is also often done redundantly by different actors for different purposes. In this context, Forzasys has developed an improved annotation and production system to produce events and summaries for live streams off-site that is in operational use. It optimizes the manual procedures and reduces the need for expensive equipment so that the events are available faster with a less cumbersome process. A live operation is depicted in Figure 1[2], where a first-level operator can follow one or more games concurrently, and by the push of a button at the time of an event, can publish an event to the users. The published event is then automatically clipped using a static "-A" seconds and "+B" seconds from the annotated event time. Then, depending on the available resources, a second level operation can be performed with a more fine-granular clipping, adding tags, textual descriptions and selecting thumbnails, i.e., a very time-consuming operation, but of great importance to improve the user experience.



(a) One person can follow multiple games. (b) Adding metadata and fine-granular clipping.

Figure 1: Swedish tagging center in live operation. Several persons involved and a lot of buttons to press in a cumbersome, error-prone and tedious manual process – *affecting costs and quality.*

Automating and making the entire process more intelligent is seen as the *holy grail* in sport video production (both broadcast and streaming services), since it would allow providing fast game highlights at a much lower cost. Here, recent developments in Artificial Intelligence (AI) technology have shown great potential, but state-of-the-art results [11, 14, 24] are far from good enough for this practical scenario that has demanding real-time requirements, where at least the detection of official events must be done in real-time and 100% accurate. Even though the detection operation has by far received most attention, it is the easiest initial operation in a tagging pipeline of multiple operations. Our idea in the *AI-PRODUCER* project is therefore to focus on the second level, namely, the more time-consuming and more expensive annotations and fine-grained production operations, where (manually)

[1] https://www.torrens.edu.au/blog/business/why-the-sports-industry-is-booming-in-2020-and-which-key-players-are-driving-growth
[2] https://forzasys.com/videos/forzify-tagging-pluss-small.mp4

detected events are enhanced and refined. Automated processes here have a large potential to both save resources, especially manual labor worth from about 4-5,000 NOK per game, and improve quality, as this last production step is often not performed at all due to time and costs. We aim for AI-based solutions to identify appropriate time interval on the video timeline defining the events' best start and stop points. Thus, instead of a human operator manually searching frame-by-frame back and forth, we will search using AI technology for scene changes, breaks in the audio, game turnovers and replays, etc., to detect appropriate points in time to define an event's time interval. While applying AI techniques to this manual labor process, we will also investigate novel analyses for feature enhancements enriching the selected scenes with more relevant meta-data than done today. Here, our proposed component will enhance textual descriptions and select appropriate thumbnails, and after the game, and even in the half-time break, produce highlight summaries, i.e., in total, greatly lessening the burden of human producers.

In summary, the goal of this project is to develop automatic algorithmic video clipping and summarization techniques, for sports in particular, reducing costs, scaling the complete annotation service by automating the most labor-intensive part, and supporting close to real-time services and thereby improving the user experience. Such a service is not just useful for soccer games, but can be applied to every live sport broadcast such as skiing or handball, thus having a huge marked to address.

2 Level of innovation

The proposed research will result in new and improved solutions for sport event generation and summarization production. This will ease the need for tedious manual labor, and the costs for creating more accurate, timely, and smoothly clipped events will be greatly reduced. The new product will both assist and potentially remove the need for extra operations to find appropriate temporal start and stop positions of an event, enhancing an event with additional metadata (tags, additional information about the involved players and teams, textual descriptions and thumbnails) producing highlight summaries by allowing the system to automatize such operations. As we describe above, there is already a large market with many opportunities for a product providing automated production services. For example:

- In a live tagging center (as they have in Sweden), the events are first detected by an operator (Figure 1a) and then clipped and enhanced with descriptions and thumbnails in a second phase (Figure 1b). The work of the second phase can be greatly reduced, and especially in scenarios requiring several versions of each clip, e.g., same event with different length. This is a common situation that adds to the manual procedure.
- In video import scenarios (as they have in Norway), where the events primarily are detected and statically clipped "-A" and "+B" seconds, the proposed system will greatly improve the clipping quality of the clips by automatically finding more natural clipping points. In such scenarios, our proposed system will also enable content owners from less favored areas (with less resources for event generation operations) to provide select events to their fans in a timely manner.
- Both in the half-time break and after a game, broadcasters and streaming service providers manually generate highlights. An automated system taking into account a time budget and an event-type prioritization to generate such a summary can greatly save resources.

It is important to point out that even though we use examples from Norway and Sweden, the same type of operations are performed all over the world for all types of sports. Thus, the business potential and market opportunities are immense and growing at an international arena.

3 Potential for value creation

The top soccer leagues in Norway and Sweden have *each* 16 teams resulting in 240 games played per year. In England and Spain, they have 380 games per league per year, and there are 304 games in Germany. Thus, each year, there is a large number of games that need efficient annotation, consuming 1,000s of hours of human labor, i.e., not to mention, all the leagues that do not have the resources to perform such annotations at all due to the lack of resources.

The proposed solution will save time in the production process for both individual clipping and highlight generation (increasing productivity), costs will be decreased, and the user experience will be improved. As mentioned above, Forzasys is already providing the annotation and production system to several leagues, and this new proposed product will greatly save resources for our customers. For example, in Scandinavia, the manpower costs per game for the event annotation only in the current setup is approximately 4-5,000 NOK per game [non-official, internal numbers from the soccer associations]. It is probably more, but assuming 30% of the time can be saved with the new AI-producer, there is a potential saving of $240 \times 1,500$ NOK $= 360,000$ NOK per league per year (just for soccer). In larger leagues, the savings will be even larger. Then, add the new requests costs to support multiple clippings of a single event (e.g., with and without replays), increasing the costs of today's systems further, and the potential of the highlight summarization component. Thus, there will be a high willingness to purchase such a product. If we then assume that we in Scandinavia alone can charge 150-200,000 NOK per year per league, and a bit lower for lower leagues, the project costs of 5,3 MNOK will be earned back in a few years. Moreover, the proposed solution will also result in a value increase of the entire video management platform making the entire streaming setup more attractive in other countries, and for other sports as well.

The full development costs and value proposition for this type of system are a bit hard to predict this early, but the market potential for automatic production systems that do automated clipping and summarization is very clear. There is no limit to the scalability of such a system, and a significant part of the international market is the goal.

4 Project participants and constellation of partners

4.1 Research-performing and financing partners

4.1.1 Companies in Norway that will be using the R&D results in their own value creation

Forzasys, the project owner, is a startup company that has brought an innovative video research prototype to the market, now running live for the four top soccer leagues in Norway and Sweden. The company has deep expertise in video solutions and building end-to-end systems with very skilled system architects and developers, and has experience in bringing a video solution to the market. Forzasys will participate with own R&D personnel who will develop, implement and integrate AI producer services (clipping and summarization) into their running video back-end, potentially extending the market and business areas of the already licensed and deployed video system. Forzasys will coordinate the data collection and knowledge transfer, build a functional prototype based on the research algorithms, and administrate the comparison of automatic operations vs. a human clipping and highlight generation.

4.1.2 R&D providers

The Holistic Systems Department (HOST) at SimulaMet investigates resource utilization and performance in complete, high-performance distributed systems, especially for multimedia applications in sport and health technology. The department has for a long time investigated AI-based systems in the areas of health, athlete monitoring and environment studies. In a collaboration with Forzasys, researchers from HOST have also initiated research in the area of soccer event detection and are applying novel AI analysis methods to the vast amount of data produced by soccer using software developed by us. Their monitoring and analysis software, for instance, is used in day-to-day operations by several hundred elite female athletes in Norway, Denmark and Portugal. Additionally, Simula Innovation will assist in protection of the IP, and for business and market evaluations. SimulaMet will be responsible for supervision of the research and providing assistance in developing the systems and interpreting the results.

4.2 Other forms of collaboration

Forzasys and SimulaMet will be the executing R&D partners in the project. However, on the sport side, there is a close collaboration with the soccer associations in Norway and Sweden where we

observe the challenges first hand, learn the requirements and may potentially recruit test personnel of the proposed technology. If needed beyond open dataset, the leagues organized by these associations are good sources of more data (already stored in the Forzasys systems).

On the academic side, the Department of Computer Science, UiT The Arctic University of Norway (UiT) focuses on fundamental concepts for run-time systems supporting large scale information access applications, and builds and evaluates run-time systems for cloud computing environments. UiT will advice on the building of effective systems in order to reduce the needed run-time for analysis. Moreover, at the department of Computer Science at the University of Oslo (UiO), new uses of computer vision algorithms in multimedia systems are studied. Both UiT and UiO will be important (external) partners providing general knowledge in the area of distributed video systems, scalable processing and computer vision.

PART 2: The R&D activities

5 Need for research

Several academic papers and articles are focusing on machine learning to resolve and automate video related problems, and to efficiently present good and accurate video events to users. Particularly, there are two important areas for research, i.e., event detection and classification and efficient video segment clipping.

5.1 Action detection

Action detection, also called spotting, has received a lot of attention. For example, two-streams convolutional neural networks (CNNs) have been tested in various variants [15, 26], and extended to include 3D convolution and pooling [10, 3]. Wang et al. [25, 30] proposed Temporal Segment Networks (TSN), and C3D [27] explored 3D convolution learning Spatio-temporal features. Tran et al. [29] used (2+1)D convolutions to allow the network to learn spatial and temporal features separately. Further approaches aim at finding temporal points in the timeline [13, 23, 11, 31, 17, 18], but even though many of these are interesting approaches and have promising results, such technology is not yet ready to be used in real-life deployments. First, these models are compute expensive. Moreover, since the results are used in an official context they must be 100% accurate, i.e., no false alarms or missed events are allowed. Thus, it is an interesting area of research, and we are already researching systems for this [24]. However, to both improve accuracy and reduce processing requirements, much more research is needed. This project will touch upon the related detection challenge, but it is not the main focus.

5.2 Event Clipping and Highlight Summarization

The other area is *event clipping* where the amount of existing work is limited. Koumaras [16] presented a shot detection algorithm, and Zawbaa [32] implemented a more tailored algorithm to handle cuts that transitioned gradually over several frames. Moreover, Zawbaa [33] classified the soccer segments as long, medium, close-up, and audience/out of field, and we observe that several papers present good results regarding scene classification [8, 33, 20]. Clips can also contain replays after an event, and replay detection can help filtering out irrelevant replay. Ren et al. [22] introduced the class labels play, focus, replay and breaks. Detecting the replay in soccer using a logo based approach has been proven to be effective using and SVM algorithm, but not so effective if using an ANN [33, 32]. Furthermore, sound may be an important modality to find good clipping points. Raventos et al. [21] used audio features to give an importance score to the highlights, and Tjondronegoro et al. [9] used audio for a summarization method detecting whistle sounds based on the frequency and pitch of the whistle sound. Based on work in [8, 22, 9], Zawbaa et al. [7] proposed a video summarization system. Finally, some work focuses on learning spatio-temporal features using various machine learning approaches [26, 2, 28], and Chen et al. [6] used entropy-based motion approach towards the problem of video segmentation in sport events.

Scene analysis is another recent and interesting research area for example analyzing spatio-temporal relations between tracked objects in the video [4], and several open challenges in real-time video scene analysis are discussed in [1]. Moreover, whether robots can take the role as a movie director controlling cameras and making clips are addressed questions [12]. However, this area is still immature, and despite its popularity, the video scene analysis is still an open challenging task, i.e., we require more accurate algorithms (specifically for time series data) and there is a dire need to extend deep learning concepts in terms of better learning of features and faster to train [1, 12]. Also, the existing research is in general targeted towards surveillance and movie making meaning that sport is still an open area of research.

These works all show a potential, and contain ideas that can be tested and utilized for AI-supported production of sport events. For example, the idea of classifying scenes could help find relevant scenes for our highlights and identify which type of rules should apply when clipping. Extracting temporal information could be very interesting to use for clipping the highlights. However, the presented results are still limited, and most importantly, it seems like the actual clipping part is not addressed, rather just identification of video properties. It is also important that the result is effective, as it is intended to produce highlight clips live. Thus, a further investigation in needed to investigate how new and existing ideas can be combined into an efficient video clipping pipeline.

6 Objectives

The primary objective in *AI-PRODUCER* is to provide existing video annotation systems (using soccer as a special case) with a new AI-component automating some of the manual, tedious work making the production easier and more efficient by providing accurate clipping (event start and stop positions in the video), adding metadata and creating summaries, i.e., greatly **reducing cost and manual labor** and **improving the user experience** due to automated and better productions. Then, our secondary objectives include:

1. Research and develop an end-to-end automated clipping and metadata enhancement solution.
2. Extend the clipping system to automatically generate game highlights.
3. Real-world validation of the system comparing the system output to human annotators.

The outcome of the project is expected to be a complete AI-producer solution which should be usable for both live and import operations, and should support generating clips matching different requirements concurrently (like different lengths of the events). Moreover, the system should be able to produce highlights summaries of a game based on some rules and priorities given by the customer, and a given time budget.

7 R&D challenges and scientific methods

Our ongoing work providing a complete end-to-end system for video management for the elite soccer leagues in Norway and Sweden has revealed challenging bottlenecks in the tedious manual operations needed to annotate game events and provide streaming services for single events and game highlights. Our aim in *AI-PRODUCER* is to automate as much as possible of this manual workflow. Our initial research shows that the first detection phase is hard to get 100% accurate (which is needed for official game events), but there might be huge savings if the work after the initial detection is performed. The amount of work for clipping and summarization is very limited, and **new, cost-efficient solutions must be researched, developed, integrated and tested for both event clipping and the following highlight generation**.

All project participants have experience in the area of experimental research, and we therefore use evolutionary prototyping to accomplish the project goals. Furthermore, the best venues for publishing research results in this area today require experimental results from real-world systems. As such, developing a proof-of-concept prototype is an important part of this project. Building running prototypes also allows for easier experimental testing, and it is a huge step towards creating a running system and a final product.

8 Project plan

8.1 Main activities ("work packages") under the project

Below, we have divided the various activities into work packages (WPs), each with different tasks and milestones. These are further put on the project timeline in the Gantt chart in Figure 2, with partner participation in Table 2, and with a category classification and cost breakdown in Table 1.

WP1: Knowledge transfer (*Responsible:* Forzasys / *R&D Category:* research)
Initially, it is important to early get a hold of relevant data where experts annotated videos with appropriate and good start and stop positions for the various events (e.g., goals, cards, shots, saves, etc.). Moreover, we must build a set of requirements from the associations and the professional producers about what they typically look for when both clip and summarize events, e.g., what is relevant and what should be prioritized, etc.? Together with our partners in Norway and Sweden, we have already started the data collection process (as part of student theses) containing both static and professional clipped events, but we also plan to use an available metadata dataset [19], and the SoccerNet [11] and SoccerNet-v2 [5] video datasets.
Suggested task(s):
T1.1 Data collection, including expert personnel tags, data preprocessing and cleaning
T1.2 Specification of the clipping and summarization rules and requirements

WP2: Automated clipping (*Responsible:* SimulaMet / *R&D Category:* industrial & experimental)
An automated solution for event clipping must be adapted to the particular properties of the video content to be analyzed and integrated into the existing workflow. Whereas the (very limited) related works described above have some potential, it must be adopted, improved, integrated and combined to solutions suitable for our special soccer scenario. Thus, we must develop solutions where we analyze the video and perform scene detection, logo identifications, audio analysis, change of cameras, game transitions and replay recognition, i.e., all information to be used to enable an accurate automated AI-based clipping operation. Furthermore, other enhancement methods will also be investigated like text description generation and thumbnail selection. Moreover, to reduce latency as much as possible, giving events faster to the users (low latency is critical for betting), we also propose to research alternative data ingest methods. Finally, we aim to build a complete end-to-end system based on the best approaches.
Suggested task(s):
T2.1 Review State-of-the-Art video clipping technology and video producer AI
T2.2 Research appropriate algorithms for clipping and metadata enhancements
T2.3 Evaluate algorithms
T2.4 Build experimental end-to-end AI-producer clipping pipeline

WP3: Summarization (*Responsible:* Forzasys / *R&D Category:* industrial & experimental)
Automated video summarization has received some attention in the research community, often combining all sorts of metadata, identification of video properties (like listed in WP2), and then trying to generate a summary. In our system, we aim to reuse the results from WP2 giving *perfectly* clipped single events. Then, given a time budget (how long the summary should be), and some priorities between events, our automated summarization idea is to select events in order based on priorities and select clipping interval for each clip to fit the time budget.
Suggested task(s):
T3.1 Review State-of-the-Art video summarization techniques.
T3.3 Research appropriate algorithms for summarization
T3.4 Evaluate algorithms
T3.5 Build experimental end-to-end AI-producer summarization pipeline

WP4: System assessment (*Responsible:* Forzasys / *R&D Category:* industrial)
One of the objectives of the proposed system is to make the manual operations better and more

efficient. Thus, the proposed system must be evaluated and compared to human producers, not only based on time to do the annotations, but also the clipping and summarization quality, i.e., according to the requirements stated in Task 1.2. Our approach here will be to involve the professionals annotators and producers in Norway and Sweden to assist in such a system assessment. This will be performed by both allowing the professionals assess the usability of the system themselves, and by having real users assess and compare both human- and machine-generated events and summaries.
Suggested task(s):
T4.1 Assessment of the final system

8.2 Budgeted project costs distributed by main activity

The classification and distribution of project costs are specified in Table 1.

				Costs:	
No.	**Title of main activity**	**Category**	**Budgeted**	**Industrial**	**Experimental**
WP1	*knowledge transfer*	*industrial*	*400*	*400*	-
T1.1	data collection	industrial	350	350	-
T1.2	specification	industrial	50	50	-
WP2	*clipping*	*mix*	*2772*	*2472*	*300*
T2.1	review state-of-the-art	industrial	180	180	-
T2.2	clipping algorithms	industrial	1772	1772	-
T2.3	algorithm evaluation	industrial	520	520	-
T2.4	end-to-end clipping pipeline	experimental	300	-	300
WP3	*summarization*	*mix*	*1915*	*1615*	*300*
T2.1	review state-of-the-art	industrial	130	130	-
T2.2	summarization algorithms	industrial	1105	1105	-
T2.3	algorithm evaluation	industrial	380	380	-
T2.4	end-to-end summarization pipeline	experimental	300	-	300
WP4	*assessment*	*industrial*	*200*	*200*	-
T4.1	final system assessment	industrial	200	200	-
Total	**Entire project**	**mix**	**5287**	**4687**	**600**

Table 1: Various activities with research categories and cost distributions.

8.3 Critical milestones for the R&D activities

M1: Collected and prepared a rich dataset (Q4 2021)
M2: First clipping algorithm and pipeline implemented (Q1 2022)
M3: Usable clipping pipeline implemented (Q2 2022)
M4: First summarization model and pipeline implemented (Q2 2022)
M5: Usable summarization pipeline implemented (Q3 2022)
M6: Full end-to-end prototype developed (Q4 2022)
M7: Assessment finished (Q4 2022)

8.4 Project organisation and management

Forzasys and SimulaMet/Simula Research Laboratory have been collaborating for a long time in various AI-based R&D projects. The *AI-PRODUCER* project will be managed and run by Forzasys (Project leader: CEO/Professor/Department Head Pål Halvorsen) in collaboration with SimulaMet (Principal investigator: Chief Research Scientist/Associate Professor Michael A. Riegler). Forzasys will be the executing part responsible for all the practical research, implementation and integration. The role of SimulaMet will be on the supervision of the project, giving ideas, and assisting in terms of discussions, analysis and review of the researched and developed solutions. Thus, as shown in Table 2, Forzasys will lead most of the WPs, but SimulaMet will lead the most algorithm, AI-heavy WP2.

9 Funding

Included in the online forms are two persons researching, developing and testing in Forzasys, research supervision at SimulaMet, and some procurement of annotation professionals for real-world testing.

Partner	Name of partner	Responsible for main activity	Participating in the following main activities
C1	Forzasys	WP1, WP3, WP4	WP2
R1	SimulaMet	WP2	WP1, WP3, WP4

Table 2: Work distribution among partners.

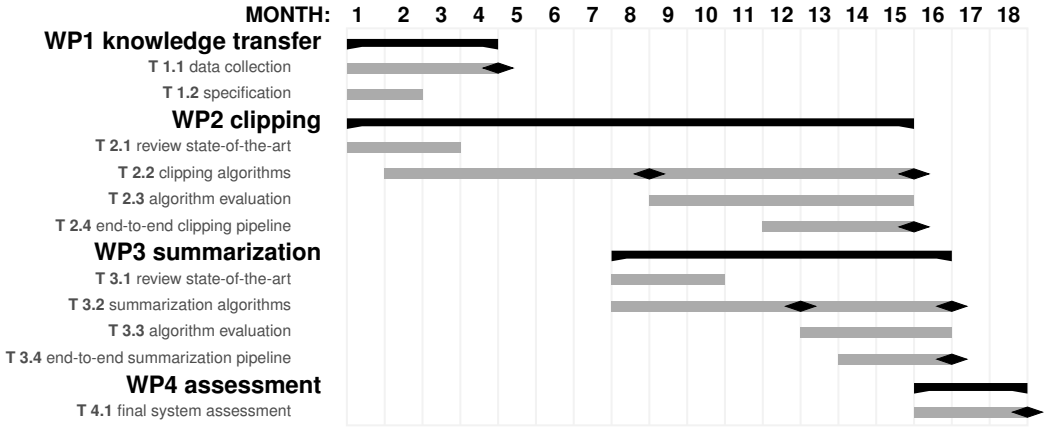


Figure 2: Gantt-chart of the WPs, tasks and key milestones (⧫, listed in Section 8.3 above).

PART 3: Plan for implementation and utilization of results

10 Realization of value creation for the Project Owner and partners

Forzasys video technology has since 2018 been built into the core of the Norwegian and Swedish soccer management systems providing a highly efficient workflow offering recording, annotation, retrieval, processing and archival system for the management of sports video and metadata. As mentioned above, *AI-PRODUCER* aims at needs observed in the current video production operations, where there are huge potentials to optimize the manual operations and increasing the users perceived quality by building a more efficient and scalable clipping and summarization component. At the end of this project, we expect to have a fully functional pipeline with the required functionality, and we will have performed a thorough system assessment and real-world validation by professional annotators. Thus, there should only be small adjustments needed (if at all) to make it a sell-able product. The current Norwegian and Swedish users of the video systems will be first customers, adding the new solution in the already established business model using licensing and per-use payments. Moreover, Forzasys is about to initiate processes to go further into the international market, and a annotation pipeline with the proposed functionality, greatly saving resources for the customers, will increase the interest of Forzasys' entire solution.

Forzasys has some processes ongoing evaluating core technologies with the aim of filing patent requests for protection of commercialization of other parts the system. Any new IPR that is deemed critical for protection will be discussed and evaluated in the course of the project. In addition, we will make sure that all partners have clear agreements for the handling of project IPR through the consortium agreement. This will reduce the risk of conflicts regarding IPR matters in the event of a successful validation/product.

11 Socio-economic benefits and contribution to sustainable development

Forzasys will initially target sport productions as the intended market. However, video clipping is a similar challenge in all broadcast and video scenarios where there is a need to segment the content, be it news, video meetings, video surveillance or online lectures. Techniques researched in this project, and even the final solution, should be transferable to all these mentioned areas. Thus, the *AI-PRODUCER* results should be of interest to a broad range of video service providers. Moreover, as the assessed

related work indicates that the addressed area is important also in the research community, the planned publications potentially can have a large impact.

AI-PRODUCER will also touch several sustainability challenges. For example, the entire video solution from Forzasys, builds on the idea of Holistic thinking and action[3], where everything is integrated and each operation is performed once, saving both computer resources and human labor (which again affect other sustainability areas.). Another example is the UN Sustainable Development Goals, including for example that we should "significantly increase access to information and communications technology and strive to provide universal and affordable access"[4]. The proposed project further improves the Forzasys system in this direction.

12 Dissemination and communication of results

Initially, the results will be presented and demonstrated to potential customers like the soccer leagues in Norway and Sweden. In this respect, the proposed technology will be interesting to demonstrate at industrial media venues like the International Broadcasting Convention (IBC). Next, we plan to broaden our portfolio of customers and will reach out to the Danish league as Forzasys already has had their first contract with Telia Denmark and FC Copenhagen. Additionally, we will branch into similar customers disseminating other types of sport, i.e., we already have had our first contacts with for instance large ski dissemination event distributors (through Olympiatoppen), handball leagues (through Telia) and sport analytics in general (ChyronHego).

From an academic view-point, the results will be disseminated to the academic community internationally, providing empirical data and evidence-based research on sales interviews. A central aim of our research effort is publication of scientific articles in peer-reviewed applied journals and conferences. The main target conferences are ACM MM, MMSys, ISM, ICME, NeurIPS and ICML. For journals, we will focus on ACM TOMM, IEEE TMM and Nature Machine Intelligence. In addition, the results will also be made available in social media and at the company website.

PART 4: Other information

13 Ethical perspectives

As there are no personal data involved, and the data to be trimmed and summarized is "official" broadcast video, there are no ethical issues in *AI-PRODUCER*. However, we will take any bias that can be introduced into account in the development of the algorithms (e.g., skin color of the players, gender, etc.). In this respect, we also plan to use explainable AI methods both for this purpose and to understand where an eventual model fails. Still, both partners have ethical guidelines internally that will be followed.

14 Gender issues (women recruitment, gender balance and perspectives)

Currently, there are no women employed in Forzasys, but there are female researchers that may participate in the project at SimulaMet. Also, in the recruitment of new project participants, we will target gender equality. Note also that the proposed technology will greatly benefit female soccer leagues, like "Toppserien" in Norway, which as examples of the leagues with less resources, greatly can benefit from the proposed technology to provide similar services in these leagues as the elite leagues for men. Noteworthy in this context is that the top two female leagues in Norway, and two female UEFA Champions League clubs in Denmark and Portugal already are daily users of Forzasys technologies.

[3]https://www.nbs.net/articles/top-12-sustainability-issues-in-2020

[4]https://www.un.org/sustainabledevelopment/infrastructure-industrialization/

References

[1] Qaisar Abbas, Mostafa E. A. Ibrahim, and M. Arfan Jaffar. Video scene analysis: an overview and challenges on deep learning algorithms. *Multimedia Tools and Applications*, 77:pages20415–20453, 2018.

[2] J. Carreira and A. Zisserman. Quo vadis, action recognition? a new model and the kinetics dataset. 2 2018.

[3] Joao Carreira and Andrew Zisserman. Quo vadis, action recognition? a new model and the kinetics dataset. In *Proc. of CVPR*, pages 4724–4733, 2017.

[4] Danilo Cavaliere, Vincenzo Loia, Alessia Saggese, Sabrina Senatore, and Mario Vento. A human-like description of scene events for a proper uav-based video content analysis. *Knowledge-Based Systems*, 178:163–175, 2019.

[5] Adrien Deliège, Anthony Cioppa, Silvio Giancola, Meisam J. Seikavandi, Jacob V. Dueholm, Kamal Nasrollahi, Bernard Ghanem, Thomas B. Moeslund, and Marc Van Droogenbroeck. Soccernet-v2 : A dataset and benchmarks for holistic understanding of broadcast soccer videos, 2020.

[6] Chen-Yu Chen et al. Motion entropy feature and its applications to event-based segmentation of sports video. 2008.

[7] Hossam M. Zawbaa et al. Machine learning-based soccer video summarization system. 2011.

[8] Peng Xu et al. Algorithms and systems for segmentation and structure analysis in soccer video. 2001.

[9] Tjondronegoro D et al. Sports video summarization using highlights and play-breaks. 2003.

[10] Christoph Feichtenhofer, Axel Pinz, and Andrew Zisserman. Convolutional two-stream network fusion for video action recognition. In *Proc. of CVPR*, pages 1933–1941, June 2016.

[11] Silvio Giancola, Mohieddine Amine, Tarek Dghaily, and Bernard Ghanem. Soccernet: A scalable dataset for action spotting in soccer videos. In *Proc. of CVPR Workshops*, pages 1711–1721, USA, June 2018.

[12] Mirko Gschwindt, Efe Camci, Rogerio Bonatti, Wenshan Wang, Erdal Kayacan, and Sebastian Scherer. Can a robot become a movie director? learning artistic principles for aerial cinematography, 2019.

[13] H. Idrees, A. R. Zamir, Y. Jiang, A. Gorban, I. Laptev, R. Sukthankar, and M. Shah. The thumos challenge on action recognition for videos "in the wild". *Computer Vision and Image Understanding*, 155:1–23, 2017.

[14] Rafal Kapela, Kevin McGuinness, Aleksandra Swietlicka, and Noel E. O'Connor. Real-time event detection in field sport videos. In *Proc. of CVPR*, 2014.

[15] Andrej Karpathy, George Toderici, Sanketh Shetty, Thomas Leung, Rahul Sukthankar, and Li Fei-Fei. Large-scale video classification with convolutional neural networks. In *Proc. of CVPR*, pages 1725–1732, June 2014.

[16] H. Koumaras, G. Gardikis, G. Xilouris, E. Pallis, and A.Kourtis. Shot boundary detection without threshold parameters. *Journal of Electronic Imaging*, 4 2006.

[17] Tianwei Lin, Xiao Liu, Xin Li, Errui Ding, and Shilei Wen. Bmn: Boundary-matching network for temporal action proposal generation. In *Proc. of ICCV*, October 2019.

[18] Tianwei Lin, Xu Zhao, Haisheng Su, Chongjing Wang, and Ming Yang. Bsn: Boundary sensitive network for temporal action proposal generation. In *Proc. of ECCV*. Springer Berlin Heidelberg, 2018.

[19] Luca Pappalardo, Paolo Cintia, et al. A public data set of spatio-temporal match events in soccer competitions. *Scientific Data*, 6(1):236, 2019.

[20] M. Rafiq, G. Rafiq, R. Agyeman, G. S. Choi, and S. Jin. Scene classification for sports video summarization using transfer learning. 2020.

[21] A. Raventós, R. Quijada, L. Torres, and F. Tarrés. Automatic summarization of soccer highlights using audio-visual descriptors. *SpringerPlus*, 4, 2015.

[22] R. Ren and J Jose. Football video segmentation based on video production strategy. 2005.

[23] Shaoqing Ren, Kaiming He, Ross Girshick, and Jian Sun. Faster r-cnn: Towards real-time object detection with region proposal networks. In C. Cortes, N. D. Lawrence, D. D. Lee, M. Sugiyama, and R. Garnett, editors, *Advances in Neural Information Processing Systems 28*, pages 91–99. Curran Associates, Inc., 2015.

[24] Olav A. Nergård Rongved, Steven A. Hicks, Vajira Thambawita, Håkon K. Stensland, Evi Zouganeli, Dag Johansen, Michael A. Riegler, and Pål Halvorsen. Real-time detection of events in soccer videos using 3d convolutional neural networks. In *Proc. of ISM*, pages 135–144, 2020.

[25] Zheng Shou, Dongang Wang, and Shih-Fu Chang. Temporal action localization in untrimmed videos via multi-stage cnns. In *Proc. of CVPR*, pages 1049–1058, June 2016.

[26] Karen Simonyan and Andrew Zisserman. Two-stream convolutional networks for action recognition in videos. In *Proc. of NIPS*, page 568–576. Curran Associates, Inc., 2014.

[27] Du Tran, Lubomir Bourdev, Rob Fergus, Lorenzo Torresani, and Manohar Paluri. Learning spatiotemporal features with 3d convolutional networks. In *Proc. of ICCV*, page 4489–4497, 2015.

[28] Du Tran, Lubomir Bourdev, Rob Fergus, Lorenzo Torresani, and Manohar Paluri. Learning spatiotemporal features with 3d convolutional networks. 10 2015.

[29] Du Tran, Heng Wang, Lorenzo Torresani, Jamie Ray, Yann LeCun, and Manohar Paluri. A closer look at spatiotemporal convolutions for action recognition. In *Proc. of CVPR*, pages 6450–6459, June 2018.

[30] Limin Wang, Yuanjun Xiong, et al. Temporal segment networks: Towards good practices for deep action recognition. In *Proc. of ECCV*, pages 20–36. Springer Berlin Heidelberg, 2016.

[31] Huijuan Xu, Abir Das, and Kate Saenko. R-c3d: Region convolutional 3d network for temporal activity detection. In *Proc. of ICCV*, 2017.

[32] H. M. Zawbaa, N. El-Bendary, and A. E. Hassanien. Machine learning-based soccer video summarization system. In *Proc. of MulGraB*, 2011.

[33] H. M. Zawbaa, N. El-Bendary, and A. E. Hassanien. Event detection based approach for soccer video summarization using machine learning. *International Journal of Multimedia and Ubiquitous Engineering*, 7, 2012.

Curriculum vitae – Pål Halvorsen

*** ROLE IN THE PROJECT**

Project manager ☒ Work package leader ☐
Project partner ☐ Other (specify) ☐ …….

*** PERSONAL INFORMATION**

*Family name, First name:	Halvorsen, Pål		
*Date of birth:	26.12.1971	*Sex:	Male
*Nationality:	Norwegian		

*** HIGHER EDUCATION/OTHER TRAINING**

	Subjects/degree/	Name of institution, country
2001	*Dr. Scient (PhD)*	*Department of Informatics, University of Oslo, NO (6 months ahead of schedule)*
1997	*Cand.Scient (MSc)*	*Department of Informatics, University of Oslo, NO*

*** POSITIONS** (academic, business, industry, public sector, national or international organisations)

Current Position(s)

	Job title/name of employer/country
2018-	*Head of Department / Chief Research Scientist, SimulaMet - Simula Metropolitan Center for Digital Engineering, NO*
2019-	*Professor, Department of Informatics, OsloMet – Oslo Metropolitan University, NO*
2019-	*Professor II, Department of Informatics, University of Oslo, NO*
2016-	*CEO Forzasys AS, NO*

Previous positions held (list)

	Job title/name of employer/country
2005-18	*Chief Research Scientist, Simula Research Laboratory, NO*
2009-18	*Professor, Department of Informatics, University of Oslo, NO*
2002-09	*Associate Professor, Department of Informatics, University of Oslo, NO*

PROJECT MANAGEMENT EXPERIENCE (since 2014)

	Project/topic/role in project/funding from
2021-24	*AVATAR* (RESEARCHER, RCN Fripro, Interview training of child-welfare and law-enforcement professionals interviewing maltreated children supported via artificial avatars)
2020-22	*FFC* (RESEARCHER, Tromsø Research Foundation, Future Female Football Center)
2018-20	*AutoCap* (PROJECT LEADER, RCN BIA, Automatic Anomaly Detection in Video Capsule Endoscopy)
2019-20	*GIRD* (RESEARCHR, RCN FORNY, Gastro-Intestinal Real-time Detection)
2016	*DigSys* (PROJECT LEADER, RCN pre-project, Non-Invasive, Scalable Automatic Screening of the GI System)
2015-16	*VUE* (PROJECT LEADER, RCN FORNY, Video system for User Engagement based on in-video metadata, sport case study)
2014-17	*EONS* (PROJECT LEADER, RCN FRINATEK, Efficient Execution of Large Workloads on Elastic Resources)
2007-14	*iAd* (PROJECT LEADER@UiO, RCN SFI, Information Access Disruptions)
2017-20	*PRIVATON* (RESEARCHER, RCN, Protecting Shared Data with Privacy Automatons)
2018	*GastroEye* (RESEARCHER, Italian, GI video capsule analysis)
2016-19	*TACS* (RESEARCHER, RCN, Trans-Atlantic Corpore Sano)
2015-	*Corpore Sano* (RESEARCHER, own financing, virtual research centre, distributed systems)
2014-17	*Unified PCIe IO* (RESEARCHER, RCN BIA, Unified PCI Express for Distributed Component Virtualization)
2012-15	*TimeIn* (RESEARCHER, RCN, Traffic behaviour of interactive time-dependent thin streams on the modern Internet)
2012-15	*RITE* (RESEARCHER, EU, Reducing Internet Transport Latency)

EXPERIENCE FROM RELEVANT RESEARCH & INNOVATION ACTIVITIES (since 2014)

	Project/type of R&I activity and R&I content /role and tasks/funding from
2019-20	*GIRD* (RESEARCHR, RCN **FORNY**, Gastro-Intestinal Real-time Detection)

2014-17	*Unified PCIe IO* (RESEARCHER, RCN **BIA**, Unified PCI Express for Distributed Component Virtualization)
2015-16	*VUE* (PROJECT LEADER, RCN **FORNY**, Video system for User Engagement based on in-video metadata)
2018-20	*AutoCap* (PROJECT LEADER, RCN **BIA**, Automatic Anomaly Detection in Video Capsule Endoscopy)
2007-14	*iAd* (PROJECT LEADER@UiO, RCN **SFI**, Information Access Disruptions)

EXPERIENCE FROM NATIONAL/INTERNATIONAL COLLABORATION/NETWORKING (since 2014)

	Activity or project / tasks and responsibilities / context/programme/framework of the collaboration and names of key partners (companies, institutions)
2014 -	More than 50 TPC memberships, co-chair memberships, associate editorships for journals, etc. See full list: http://home.simula.no/~paalh/conferences.html

OTHER MERITS RELEVANT TO THE PROJECT

My research interests include multimedia and distributed systems, in particular, system performance, video analysis and delivery, sport and medical applications, machine/deep learning.

Total number of publications (journals, peer-review conferences): ~300
Full list at: http://home.simula.no/~paalh/publications/
According to Google Scholar (https://scholar.google.no/citations?user=hru0ei0AAAAJ&hl=en), I have about 4500 citations and an h-index of 33

10 selected publications (since 2019):

1. ***"Using 3D Convolutional Neural Networks for Real-Time Detection of Soccer Events",*** Olav A. Nergård Rongved, Steven A. Hicks, Vajira Thambawita, Håkon K. Stensland, Evi Zouganeli, Dag Johansen, Cise Midoglu, Michael A. Riegler, and Pål Halvorsen, TO APPEAR in International Journal of Semantic Computing, 2021
2. ***"Real-Time Detection of Events in Soccer Videos using 3D Convolutional Neural Networks",*** Olav A. Nergård Rongved, Steven A. Hicks, Vajira Thambawita, Håkon K. Stensland, Evi Zouganeli, Dag Johansen, Michael A. Riegler, and Pål Halvorsen, Proceeding of the IEEE International Symphosium of Multimeida (ISM), 2020
3. ***"HyperKvasir, a comprehensive multi-class imageand video dataset for gastrointestinal endoscopy",*** Hanna Borgli, Vajira Thambawita, Pia H. Smedsrud, Steven Hicks ,Debesh Jha, Sigrun L. Eskeland, Kristin Ranheim Randel, Konstantin Pogorelov, Mathias Lux, Duc Tien Dang Nguyen, Dag Johansen, Carsten Griwodz, Hakon Stensland, Enrique Garcia-Cej, Peter T. Schmidt, Hugo Hammer, Michael A. Riegler, Pål Halvorsen, Thomas de Lange, Nature Scientifi, Data, 2020
4. ***"Scalable Infrastructure for Efficient Real-Time Sports Analytics",*** Håvard Johansen, Dag Johansen, Tomas Kupka, Michael A. Riegler and Pål Halvorsen, Proceedings of Workshop on Action Modelling for Interaction and Analysis in Smart Sports and Physical Education (MAIStroPE), 2020

5. ***"Machine Learning-Based Analysis of Sperm Videos and Participant Data for Male Fertility Prediction"***, Steven A. Hicks, Jorunn M. Andersen, Oliwia Witczak, Vajira Thambawita, Pål Halvorsen, Hugo L. Hammer, Trine B. Haugen, Michael A. Riegler, Nature Scientific Reports, Volume 9, Article number 16770, November 2019
6. ***"An Extensive Study on Cross-Dataset Bias and Evaluation Metrics Interpretation for Machine Learning Applied to Gastrointestinal Tract Abnormality Classification"***, Vajira Thambawita, Debesh Jha, Hugo Hammer, Håvard D. Johansen, Dag Johansen, Pål Halvorsen, Michael Riegler, ACM Transactions on Computing for Healthcare, Article no.: 17, June 2020
7. ***"Deep Learning for Automatic Geneation of Endoscopy Reports",*** Steven Hicks, Pia H. Smedsrud, Michael A. Riegler, Thomas de Lange, Andreas Petlund, Sigrun L. Eskeland, Konstantin Pogorelov, Peter T. Schmidt, Pål Halvorsen, Gastrointestinal Endoscopy, Volume 89, Issue 6, Supplement, June 2019
8. ***"Real-time Analysis of Physical Performance Parameters in Elite Soccer",*** Kim Andreassen, Dag Johansen, Håvard Johansen, Ivan Baptista, Svein A. Pettersen, Michael Riegler, Pål Halvorsen, Proceedings of the ACM International Workshop on Content-Based Multimedia Indexing (CBMI), Dublin, Ireland, September 2019
9. ***"Effcient Live and On-Demand Tiled HEVC 360 VR Video Streaming"***, Mattis Jeppsson, Håvard N. Espeland, Tomas Kupka, Ragnar Langseth, Andreas Petlund, Peng Qiaoqiao, Chuansong Xue, Dag Johansen, Konstantin Pogorelov, Håkon Stensland, Carsten Griwodz, Michael Riegler, Pål Halvorsen, International Journal of Semantic Computing Vol. 13, No. 3, 2019
10. ***"Summarizing E-Sports Matches and Tournaments - The Example of Counter-Strike: Global Offensive"***, Mathias Lux, Pål Halvorsen, Duc-Tien Dang-Nguyen, Håkon K. Stensland, Manjo Kesavulu, Martin Potthast, Michael Riegler, Proceedings of International Workshop on Immersive Mixed and Virtual Environment Systems (MMVE), Amherst, MA, USA, June 2019

Company creation:

- 2018: Co-founder Orca Labs AS - https://www.orcalabs.no
- 2018: Co-founder Augere Medical AS - https://augere.md
- 2014: Co-founder Forzasys AS - https://forzasys.com

Granted Patents:

"Data segmentation, request and transfer method", Dominik Kaspar, Kristian R. Evensen, Paal E. Engelstad, Audun F. Hansen, Carsten Griwodz, Pål Halvorsen, US 20110213827

Selected awards:

- IEEE ISM 2018 Best paper award
- MediaEval 2018 Distinctive Mention award
- IEEE CBMS 2018 Best paper award
- IFI@UiO Very good course 2010: INF5071
- NPC 2009 Best Student Paper Award
- IFI@UiO Extraordinary good course 2009: INF5063
- IFI@UiO Best Lecturer Award 2007
- LCN 2006 Best Paper Award
- NOSSDAV 2006 Best Paper Award

Curriculum vitae

*** ROLE IN THE PROJECT**

Project manager	☐	Work package leader	X	
Project partner	☐	Other (specify)	☐	……

*** PERSONAL INFORMATION**

*Family name, First name:	Kupka, Tomas		
*Date of birth:	02.05.1984	*Sex:	M
*Nationality:	Slovak		

*** HIGHER EDUCATION/OTHER TRAINING**

	Subjects/degree/	Name of institution, country
2013	PhD	Universitetet i Oslo, Norway
2007	Dipl.-Inf. (Master)	Technische Universität Berlin, Germany

*** POSITIONS** (academic, business, industry, public sector, national or international organisations)

Current Position

	Job title/name of employer/country
2014-	Chief Architect/ForzaSys AS/Norway

Previous positions held (list)

	Job title/name of employer/country
2013-2016	Senior Software Engineer/Telenor Digital/Norway
2009-2013	Research Fellow/Simula Research Laboratory/Norway
2008-2009	IT Specialist/IBM/Slovakia
2007-2008	Programmer/Tempest/Slovakia
2005-2007	Student assistant/Fraunhofer FOKUS/Germany

PROJECT MANAGEMENT EXPERIENCE (if applicable)

	Project/topic/role in project/funding from
2014-	Forzify/Video streaming platform/Architect/ForzaSys AS

EXPERIENCE FROM RELEVANT RESEARCH & INNOVATION ACTIVITIES (if applicable)

	Project/type of R&I activity and R&I content /role and tasks/funding from
2018-2020	AutoCap (researcher and developer, RCN BIA, Automatic Anomaly Detection in Video Capsule Endoscopy)
2015-2016	VUE (researcher and developer, RCN FORNY, Video system for User Engagement based on in-video metadata, sport case study)

EXPERIENCE FROM NATIONAL/INTERNATIONAL COLLABORATION/NETWORKING (if applicable)

	Activity or project / tasks and responsibilities / context/programme/framework of the collaboration and names of key partners (companies, institutions)

OTHER MERITS RELEVANT TO THE PROJECT

Possibly relevant publications on video streaming and machine learning:

Vajira Thambawita, Steven Alexander Hicks, Hanna Borgli, Håkon Stensland, Debesh Jha, Martin Kristoffer Svensen, Svein Arne Pettersen, Dag Johansen, Håvard Dagenborg Johansen, Susann Dahl Pettersen, Simon Nordvang, Sigurd Pedersen, Anders T Gjerdrum, Tor Morten Grønli, Per Morten Fredriksen, Ragnhild Eg, Kjeld Steenbjerg Hansen, Siri Fagernes, Christine Claudi, Andreas Biørn-Hansen, Duc Tien Nguyen, Tomas Kupka, Hugo Lewi Hammer, Ramesh Jain, Michael Riegler, Pål Halvorsen. PMData: a sports logging dataset. In Proceedings of the ACM Multimedia Systems (MMSYS), Istanbul, Turkey, 2020

Håvard D. Johansen, Dag Johansen, Tomas Kupka, Michael A. Riegler, and Pål Halvorsen. 2020. Scalable Infrastructure for Efficient Real-Time Sports Analytics. In *Companion Publication of the 2020 International Conference on Multimodal Interaction* (*ICMI '20 Companion*). Association for Computing Machinery, New York, NY, USA, 230–234.

Mattis Jeppsson, Håvard N. Espeland, Tomas Kupka, Ragnar Langseth, Andreas Petlund, Peng Qiaoqiao, Chuansong Xue, Dag Johansen, Konstantin Pogorelov, Håkon Stensland, Carsten Griwodz, Michael Riegler, Pål Halvorsen. Efficient Live and On-Demand Tiled HEVC 360 VR Video Streaming. International Journal of Semantic Computing Vol. 13, No. 3, 2019, pp. 1–25

Theodor Wiik, Håvard D. Johansen, Svein-Arne Pettersen, Ivan Baptista, Tomas Kupka, Dag Johansen, Michael Riegler, Pål Halvorsen. Predicting Peek Readiness-to-Train of Soccer Players Using Long Short-Term Memory Recurrent Neural Networks.
Proceedings of the ACM International Workshop on Content-Based Multimedia Indexing (CBMI), Dublin, Ireland, September 2019

Mattis Jeppsson, Håvard N. Espeland, Tomas Kupka, Ragnar Langseth, Andreas Petlund, Peng Qiaoqiao, Chuansong Xue, Konstantin Pogorelov, Michael Riegler, Dag Johansen, Carsten Griwodz, Pål Halvorsen. Efficient Live and on-Demand Tiled HEVC 360 VR Video Streaming - Best paper award. Proceeding of IEEE International Symposium on Multimedia (ISM), Taichung, Taiwan, December 2018

Vamsidhar R. Gaddam, Ragnar Langseth, Håkon K. Stensland, Carsten Griwodz, Michael Riegler, Tomas Kupka, Håvard Espeland, Dag Johansen, Håvard D. Johansen, Pål Halvorsen. Camera Synchronization for Panoramic Videos" (book chapter)
In: Mario Montagud, Pablo Cesar, Fernando Boronat, Jack Jansen (eds), MediaSync, Springer, 2018, pp 565-592

Pogorelov, Konstantin & Ostroukhova, Olga & Petlund, Andreas & Halvorsen, Pål & de Lange, Thomas & Espeland, Håvard & Kupka, Tomas & Griwodz, Carsten & Riegler, Michael. (2018). Deep Learning and Handcrafted Feature Based Approaches for Automatic Detection of Angiectasia.

Konstantin Pogorelov, Olga Ostroukhova, Andreas Petlund, Carsten Griwodz, Pål Halvorsen, Thomas de Lange, Håvard Nygaard Espeland, Tomas Kupka and Michael Riegler. Automatic Detection of Angiectasia: Evaluation of Deep Learning and Handcrafted Approaches. Proceeding of the IEEE International Conference on Biomedical and Health Informatics (BHI), Las Vegas, USA, March 2018

Kristian Evensen, Tomas Kupka, Haakon Riiser, Pengpeng Ni, Ragnhild Eg, Carsten Griwodz, and Pål Halvorsen. 2014. Adaptive media streaming to mobile devices: challenges, enhancements, and recommendations. *Adv. MultiMedia* 2014, Article 10 (January 2014)

Tomas Kupka. 2013. On the HTTP segment streaming potentials and performance improvements. *SIGMultimedia Rec.* 5, 2 (June 2013), 14–15.

Tomas Kupka, Pål Halvorsen, and Carsten Griwodz. 2012. Performance of on-off traffic stemming from live adaptive segmented HTTP video streaming. In *Proceedings of the 2012 IEEE 37th Conference on Local Computer Networks (LCN 2012)* (*LCN '12*). IEEE Computer Society, USA, 401–409.

Tomas Kupka, Pål Halvorsen, and Carsten Griwodz. 2011. An evaluation of live adaptive HTTP segment streaming request strategies. In *Proceedings of the 2011 IEEE 36th Conference on Local Computer Networks* (*LCN '11*). IEEE Computer Society, USA, 604–612.

Pål Halvorsen, Dag Johansen, Bjørn Olstad, Tomas Kupka, and Sverre Tennøe. 2010. VESP: enriching enterprise document search results with aligned video summarization. In *Proceedings of the 18th ACM international conference on Multimedia* (*MM '10*). Association for Computing Machinery, New York, NY, USA, 1603–1604

Curriculum vitae

* ROLE IN THE PROJECT

Project manager	☐	Work package leader	☒
Project partner	☐	Other (specify)	☐ .....

* PERSONAL INFORMATION

*Family name, First name:	Riegler, Michael Alexander		
*Date of birth:	18.09.1984	*Sex:	Male
*Nationality:	Austrian		

* HIGHER EDUCATION/OTHER TRAINING

	Subjects/degree/	Name of institution, country
2017	*Dr. Scient (PhD)*	*Department of Informatics, University of Oslo, NO (submitted 12 months ahead of schedule)*
2014	*Magister (Mag.)*	*Department of Informatics and Department of Economics, University of Klagenfurt, AT*

* POSITIONS (academic, business, industry, public sector, national or international organisations)

Current Position

	Job title/name of employer/country
2019-	*Chief Research Scientist, SimulaMet - Simula Metropolitan Center for Digital Engineering, NO*

Previous positions held (list)

	Job title/name of employer/country
2019-2020	*Adjunct Associate Professor, Kristiania University College, NO*
2018-2019	*Senior Research Scientist, SimulaMet- Simula Metropolitan Center for Digital Engineering, NO*
2017-2018	*Research Scientist, Simula Research Laboratory, NO*
2014-2017	*PhD Student, Simula Research Laboratory, NO*
2014	*Research Staff Member, Department of, University of Klagenfurt, AT*

PROJECT MANAGEMENT EXPERIENCE (if applicable)

	Project/topic/role in project/funding from
2021-2026	*Interview training of child-welfare and law-enforcement professionals interviewing maltreated children supported via artificial avatars (*Researcher, CRN Fripro, 12MNOK)
2020-2022	*FFC* (Researcher, Tromsø Research Foundation, Future Female Football Center)
2019-2024	*ReproAI* (Researcher, CRN FRIMEDBIO, improved assisted human reproduction technology using AI, 12MNOK)
2016	*DigSys* (Researcher, CRN pre-project, Non-Invasive, Scalable Automatic Screening of the GI System, 500KNOK)
2014-2017	*EONS* (Researcher, CRN FRINATEK, Efficient Execution of Large Workloads on Elastic Resources, 12MNOK)
2017-2020	*PRIVATON* (Researcher, CRN, Protecting Shared Data with Privacy Automatons, 12MNOK)
2018-2023	*PACER* (Researcher, CRN, Patient-Centric Engineering in Rehabilitation, 12MNOK)

EXPERIENCE FROM RELEVANT RESEARCH & INNOVATION ACTIVITIES (if applicable)

	Project/type of R&I activity and R&I content /role and tasks/funding from
2019-2020	*GIRD* (RESEARCHR, RCN **FORNY**, Gastro-Intestinal Real-time Detection)
2018-2020	*AutoCap* (Researcher, CRN BIA, Automatic Anomaly Detection in Video Capsule Endoscopy, 12MNOK)
2018	*GastroEye* (Researcher, Italian, GI video capsule analysis, 700KNOK)
2017-2019	*INTROMAT* (Researcher, CRN Lighthouse, INTROducing Mental health through Adaptive Technology, 72MNOK)

EXPERIENCE FROM NATIONAL/INTERNATIONAL COLLABORATION/NETWORKING (if applicable)

	Activity or project / tasks and responsibilities / context/programme/framework of the collaboration and names of key partners (companies, institutions)
2014-	Multimedial Workshop organization, Different roles, University of Delft, Netherlands

OTHER MERITS RELEVANT TO THE PROJECT

My research interests include machine learning, multimedia and distributed systems. In particular, my experience cover machine learning with a focus on deep learning and system performance.

Total number of publications (journals, peer-review conferences): ~219
Google Scholar https://scholar.google.no/citations?user=Vd_ApDoAAAAJ&hl=en
Number of citations: 2298, h-index: 26, i10-index: 60

10 selected publications (since 2019):

1. ***"Using 3D Convolutional Neural Networks for Real-Time Detection of Soccer Events",*** Olav A. Nergård Rongved, Steven A. Hicks, Vajira Thambawita, Håkon K. Stensland, Evi Zouganeli, Dag Johansen, Cise Midoglu, Michael A. Riegler, and Pål Halvorsen, TO APPEAR in International Journal of Semantic Computing, 2021

2. ***"HyperKvasir, a comprehensive multi-class imageand video dataset for gastrointestinal endoscopy",*** Hanna Borgli, Vajira Thambawita, Pia H. Smedsrud, Steven Hicks ,Debesh Jha, Sigrun L. Eskeland, Kristin Ranheim Randel, Konstantin Pogorelov, Mathias Lux, Duc Tien Dang Nguyen, Dag Johansen, Carsten Griwodz, Hakon Stensland, Enrique Garcia-Cej, Peter T. Schmidt, Hugo Hammer, Michael A. Riegler, Pål Halvorsen, Thomas de Lange, Nature Scientifi, Data, 2020

3. ***"PMData: a sports logging dataset"***, Vajira Thambawita, Steven Alexander Hicks, Hanna Borgli, Håkon Stensland, Debesh Jha, Martin Kristoffer Svensen, Svein Arne Pettersen, Dag Johansen, Håvard Dagenborg Johansen, Susann Dahl Pettersen, Simon Nordvang, Sigurd Pedersen, Anders T Gjerdrum, Tor Morten Grønli, Per Morten Fredriksen, Ragnhild Eg, Kjeld Steenbjerg Hansen, Siri Fagernes, Christine Claudi, Andreas Biørn-Hansen, Duc Tien Nguyen, Tomas Kupka, Hugo Lewi Hammer, Ramesh Jain, Michael Riegler, Pål Halvorsen, Proceedings of the ACM Multimedia Systems (MMSYS), Istanbul, Turkey, 2020

4. ***"Scalable Infrastructure for Efficient Real-Time Sports Analytics",*** Håvard Johansen, Dag Johansen, Tomas Kupka, Michael A. Riegler and Pål Halvorsen, Proceedings of Workshop on Action Modelling for Interaction and Analysis in Smart Sports and Physical Education (MAIStroPE), 2020

5. ***"Machine Learning-Based Analysis of Sperm Videos and Participant Data for Male Fertility Prediction"***, Steven A. Hicks, Jorunn M. Andersen, Oliwia Witczak, Vajira Thambawita, Pål Halvorsen, Hugo L. Hammer, Trine B. Haugen, Michael A. Riegler, Nature Scientific Reports, Volume 9, Article number 16770, November 2019

6. ***"An Extensive Study on Cross-Dataset Bias and Evaluation Metrics Interpretation for Machine Learning Applied to Gastrointestinal Tract Abnormality Classification"***, Vajira Thambawita, Debesh Jha, Hugo Hammer, Håvard D. Johansen, Dag Johansen, Pål Halvorsen, Michael Riegler, ACM Transactions on Computing for Healthcare, Article no.: 17, June 2020

7. ***"Deep Learning for Automatic Geneation of Endoscopy Reports",*** Steven Hicks, Pia H. Smedsrud, Michael A. Riegler, Thomas de Lange, Andreas Petlund, Sigrun L. Eskeland, Konstantin Pogorelov, Peter T. Schmidt, Pål Halvorsen, Gastrointestinal Endoscopy, Volume 89, Issue 6, Supplement, June 2019

8. ***"Real-time Analysis of Physical Performance Parameters in Elite Soccer",*** Kim Andreassen, Dag Johansen, Håvard Johansen, Ivan Baptista, Svein A. Pettersen, Michael Riegler, Pål Halvorsen, Proceedings of the ACM International Workshop on Content-Based Multimedia Indexing (CBMI), Dublin, Ireland, September 2019

9. ***"Effcient Live and On-Demand Tiled HEVC 360 VR Video Streaming"***, Mattis Jeppsson, Håvard N. Espeland, Tomas Kupka, Ragnar Langseth, Andreas Petlund, Peng Qiaoqiao, Chuansong Xue, Dag Johansen, Konstantin Pogorelov, Håkon Stensland, Carsten Griwodz, Michael Riegler, Pål Halvorsen, International Journal of Semantic Computing Vol. 13, No. 3, 2019

10. ***"Summarizing E-Sports Matches and Tournaments - The Example of Counter-Strike: Global Offensive"***, Mathias Lux, Pål Halvorsen, Duc-Tien Dang-Nguyen, Håkon K. Stensland, Manjo Kesavulu, Martin Potthast, Michael Riegler, Proceedings of International Workshop on Immersive Mixed and Virtual Environment Systems (MMVE), Amherst, MA, USA, June 2019

Selected awards:

- One of the five ESHRE 2019 most promising researchers (ESRHE Young Ambassador), European Society of Human Reproduction and Embryology
- *Researcher of the Year 2018 at Simula Research Laboratory, Simula Research Laboratory*
- *One of four Rising Stars/Leaders in the multimedia research community, ACM SIGMM 2018*
- IEEE ISM 2018 Best paper award
- MediaEval 2018 Distinctive Mention award
- IEEE CBMS 2018 Best paper award
- *TEWI Hall of fame – 2017 Award from University of Klagenfurt for most successful alumni*
- *Award for best performing student 2012/2013 from the Faculty of Management and Economics at the University of Klagenfurt*

Member of:

- Expert group member on artificial intelligence in health, The Norwegian Board of Technology
- Member of the Academy of of Norway, Akademiet for yngre forskere

Attachment to grant application for an Innovation Project for the Industrial Sector.
Project title: AI-Producer - AI-based Video Clipping and Summarization of Sport Events

Information about applicant and partner companies

Company name:	Forzasys AS		
Enterprise no.:	913 968 026	Year established:	2014
Company website:	forzasys.com		

Key figures for most recent accounting year (all figures to be provided in NOK million). ***Specify year for the accounts (FTE= Full time equivalents):***			
No. of employees:	5*	No. of FTEs performed by own employees:	
No. of R&D personnel:	5	No. of R&D FTEs performed by own employees:	

Annual turnover:	3989677 NOK
Balance sheet total:	7813250 NOK
Earnings:	-68661 NOK
Total R&D expenditures:	~3500000** NOK

Information about ownership:	
Do one or more enterprises hold an ownership interest of 25% or more in the company? (Yes/No)	Yes
Does the company hold an ownership interest of 25% or more in one or more enterprises? (Yes/No)	No
Is the company part of larger concern? (Yes/No) If so, provide the name of the concern:	No

Contact person for annual report/annual accounts and further information about the company:	
Name and email address of contact person:	Pål Halvorsen, paalh@forzasys.com

*At the end of 2020, Forzasys had 7 employees, but 2 started full-time in a Forzasys spin-off from January 2021. At the time of writing there are 5 persons in under contract with Forzasys, but still 2 more will be permanently moved to the spin-off from end of May 2021. Forzasys is therefore currently trying to increase the staff again.
**A bit hard to say, but almost all work in Forzasys is R&D.

Business areas:

Forzasys' main business areas are innovative end-to-end video systems running live in top soccer leagues in Norway and Sweden, where the provided solution operates on all levels of the production and dissemination pipeline. The goal is to efficiently integrate all operations and services into one system removing all redundant work and data storage, and at the same time reduce manual labour.
Our primary customer targets are content owners like league associations, broadcasters or clubs. We are currently serving both leagues and clubs, and for the leagues, they are working on integrating the solution into the broadcasters' systems.

Target markets and position:

Forzasys has a leading position in the current Scandinavian market. Our solution is integrated into the core of the entire production pipeline, and an increasing number of services are moved to our solutions. Now that we have proven the value, benefits and stability of our system through several years of stable operations, we also aim at targeting other sports and video areas, not only in Scandinavia, but also broader.

Planned company results:

The goal of this project is to develop automatic algorithmic video clipping and summarization techniques, for sports in particular, reducing costs, scaling the complete annotation and production service by automating the most labour-intensive operations. Such a service is not just useful for soccer

games, but can be applied to every live sport broadcast such as skiing or handball, thus having a huge marked to address. In particular, the outcome of the project is expected to be a complete AI-producer solution which should be usable for both live and import operations, and should support generating clips matching different requirements concurrently (like different lengths of the events). Moreover, the system should be able to produce highlights summaries of a game based on rules and priorities given by the customer, and a given time budget. The business idea is that such a solution will be added to and extend the current production services provided by Forzasys in the production rooms lessening the burden of the personnel and generating high-quality events and summaries much faster.

Role and contributions:

As described in the proposal, Forzasys will perform most of the R&D in the project. The company is built on research results where the people (having master and PhD degrees) who researched and developed the initial ideas still run the company. Moreover, having already tight connections to researchers, and a technical advisory board consisting of professors, the research competence should be well covered. Forzasys has also participated in developing AI-based solutions for example for medicine (resulting in a spin-off) and for athlete monitoring. Lately, Forzasys also has participated and enabled AI-based student work in soccer video analysis and event detection. Thus, content analysis and AI-based systems also go into the company's area of expertise.

Company value creation:

As described in the proposal document, the proposed solution have a huge potential to reduce costs, lessen manual labour and provide faster productions by providing automated event clipping, metadata enhancements and summary generation services. There is a huge number of games broadcasted and streamed in various soccer leagues world-wide, and the proposed solutions will give increased productivity. Moreover, the proposed solution will also result in a value increase of the entire video management platform making the entire streaming setup more attractive in other countries, and for other sports as well. Still, the full development costs and value propositions for this type of system are a bit hard to predict this early, but the market potential is large.

Attachment to grant application for an Innovation Project for the Industrial Sector.
Project title: AI-Producer - AI-based Video Clipping and Summarization of Sport Events

Information about applicant and partner companies

Company name:	Simula Metropolitan Center for Digital Engineering AS			
Enterprise no.:	920 203 612		Year established:	2018
Company website:	www.simulamet.no			
Key figures for most recent accounting year (all figures to be provided in NOK million). ***Specify year for the accounts (FTE= Full time equivalents):***				
No. of employees:	59	No. of FTEs performed by own employees:		59
No. of R&D personnel:	47,5	No. of R&D FTEs performed by own employees:		47,5
Annual turnover:				72 170 kNOK
Balance sheet total:				45 536 kNOK
Earnings:				6 807 kNOK
Total R&D expenditures:				100 %
Information about ownership:				
Do one or more enterprises hold an ownership interest of 25% or more in the company? (Yes/No)				No
Does the company hold an ownership interest of 25% or more in one or more enterprises? (Yes/No)				No
Is the company part of larger concern? (Yes/No) If so, provide the name of the concern: Simula Research Laboratory AS				Yes
Contact person for annual report/annual accounts and further information about the company:				
Name and email address of contact person:	Monica Eriksen, monica@simula.no			

Simula Metropolitan Center for Digital Engineering (SimulaMet) is a new research unit that is jointly owned by Simula Research Laboratory and OsloMet – Oslo Metropolitan University. It is the home of Simula's research activities on networks and communications, machine learning and IT management, and it is OsloMet´s strategic partner in research and postgraduate education. SimulaMet is organized as a limited company.

Except for research itself, SimulaMet does not sell products, and thus, have not particular markets. The research center has its focus areas as listed above, but has no particular target application scenarios or customers. That said, the partner research department (Holistic Systems) has focus areas directly matching the proposal. The department has for a long time investigated AI-based systems in the areas of health, sports and environment studies – for real-world environments and users. In a collaboration with Forzasys, researchers from HOST have also initiated research in the area of soccer event detection and are applying novel AI analysis methods to the vast amount of data produced by soccer. Thus, the research department has a good position in the research community, having papers being cited, asked to organize workshops and competitions, and requests for collaborations.

SimulaMet's goals and objectives in the proposed project are to produce interesting and relevant research and generate ideas potentially being used by industry or society in general. This project targets a real-world open challenge, and the potential for impact is large. Thus, we seek interesting challenges and research problems, that can result in good published papers, student theses, and research prototypes, i.e., the value for our research department is the research, the prototypes, experiences and the resulting papers that will strengthen our research profile and can be used further in our future research in AI, video analysis and sports in general. The proposal aims for procurement of time from SimulaMet

researchers. We will involve our researchers in HOST already having the experience in the area of AI, sports and video analysis.