# Mobile and Mounting Solutions for a Multi-Camera Rig for Live Recordings of Open Heart Surgery

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***Abstract*—At the Children's Heart Center of Skåne University Hospital (BUS) there is an ongoing project with live recordings of open heart surgeries. These recordings will be used for educational purposes, for planning of future surgeries, as well as for evaluating the surgical procedures. Currently, the recordings are made using two cameras that are positioned above the operating table on a temporary mounting rig. The problem with only using two cameras is that they are unable to capture every desired angle and also that the personnel will occasionally cover the cameras field of view. Therefore, the surgeons wish to begin recording the procedures using seven cameras that are positioned tactically to retain a clear field of view as much as possible. In order to properly utilize a multi-camera system there is a need for a mobile mounting solution that can support the weight of multiple cameras, is easily installed or uninstalled in the operating rooms, and is tailored to fit the stressful environment during an open heart surgery. The project to actualize the mobile mounting solution was performed at the Children's Heart Center of Skåne University Hospital in collaboration with ProSwede Invest AB. The optimal solution to best suit the needs and wishes of the surgical environment at BUS is to have the multi-camera rig permanently mounted to the ceiling in the operating room and to connect the rig to a steering-arm which is attached to the operating table prior to a surgical procedure.**

## I. Introduction

ADVANCMENTS in surgical techniques and technologies have revolutionized the field of open heart surgery, improving patient outcomes and driving the need for more sophisticated recording methods. Traditional single-camera setups, commonly used in surgical settings, often fail to capture the complexity and nuances of these intricate procedures. To overcome these limitations, this paper presents the design and production of a mobile and mounting solution for a multi-camera rig specifically tailored for live recordings of open heart surgery. This innovative rig offers a range of benefits, including enhanced surgical education, improved quality assurance, potential cost savings for the hospital, and opportunities for future research and development.

The necessity for a multi-camera rig in open heart surgeries stems from the demand for comprehensive visualization of the surgical field. By capturing different angles and perspectives simultaneously, the multi-camera rig allows medical professionals to observe intricate details and surgical techniques that may not be visible through a single camera viewpoint. This comprehensive visual representation enhances the educational value for surgical trainees, enabling them to acquire a deeper understanding of the procedures and potentially improving their surgical skills [1] [2]. Additionally, experienced surgeons can utilize the recorded footage for knowledge exchange, fostering continuous improvement and collaboration among peers [3].

The adoption of a multi-camera rig also has the potential to lead to significant cost savings for the hospital. Traditional surgical training and post-operative follow-ups often require the physical presence of experts, resulting in substantial travel costs. By capturing surgeries in high-definition through the multi-camera rig, telemedicine and virtual consultations can be facilitated, reducing the need for physical travel and optimizing resource allocation [4]. This not only saves costs but also enhances accessibility to specialized expertise, particularly in remote areas or regions with limited access to specialized cardiac care.

Overall, this paper aims to provide a comprehensive understanding of the design, production, and evaluation of a mobile and mounting solution for a multi-camera rig in live recordings of open heart surgeries. Through this project, we seek to address the existing gaps in surgical recording methods and contribute to the advancement of surgical education and quality assurance. By presenting the technical details and manufacturing evaluation of our multi-camera rig, we aim to contribute to the knowledge base in this field and provide practical insights for healthcare institutions considering the implementation of similar solutions.

### A. Background

Previous work in the field of mobile and mounting solutions for surgical recordings has primarily focused on general surgery procedures. While some studies have demonstrated the benefits of multi-camera setups in improving surgical education and quality assurance, the specific application to open heart surgeries remains limited [5]. Given the complexity and unique requirements of open heart surgeries, there is a clear need for specialized mobile and mounting solutions to capture the intricacies of these procedures effectively.

The current state of the art in surgical recordings emphasizes the importance of capturing comprehensive views of the surgical field. Studies have shown that utilizing a greater number of cameras significantly enhances the educational value and allows for better analysis of surgical techniques [6]. However, relying on too few cameras restricts the ability to observe critical aspects of the surgery, potentially missing

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important details that may affect patient outcomes. Therefore, a multi-camera rig offers the potential to bridge this gap by capturing multiple angles simultaneously, providing a more comprehensive visual representation of the surgical procedure.

In recent years, the need for improved surgical documentation and analysis has gained prominence [7]. The National Heart, Lung, and Blood Institute reported that more than 2 million open heart surgeries are performed annually worldwide [8], highlighting the significance of developing advanced recording methods to enhance patient care and surgical outcomes. With the increasing complexity of open heart surgeries and the growing demand for specialized cardiac care, the development of a mobile and mounting solution for a multi-camera rig has become crucial.

Furthermore, advancements in technology have made it possible to capture high-resolution footage and transmit it in real-time to remote locations [9]. This opens up possibilities for telemedicine, allowing experts to remotely review surgeries, provide guidance, and collaborate with surgical teams without the need for physical presence. The multi-camera rig, designed for live recordings, can facilitate such telemedicine applications, leading to improved access to specialized expertise, reduced costs associated with expert travel, and enhanced patient care.

The limitations of existing single-camera setups in open heart surgeries have been recognized by surgeons and researchers. With limited visual perspectives, these setups may fail to capture critical aspects of the surgical field, potentially compromising the effectiveness of surgical education and quality assurance. The development of a multi-camera rig specifically tailored for open heart surgeries addresses these limitations by providing a comprehensive and dynamic visual documentation of the procedures.

The integration of additional references provides further support for the benefits of multi-camera setups in surgical education and quality assurance [4] as well as the advancements in image guidance and interactive robotic control for surgical interventions [9]. By incorporating these references, we can establish the current knowledge landscape and the need for a specialized mobile and mounting solution for live recordings of open heart surgeries.

In the subsequent sections, we will delve into the details of our rig's design and production process, including the selection of mounting systems and recording equipment. We will also describe the integration challenges encountered during the development phase and the steps taken to ensure compatibility with the surgical environment.

### B. Hypothesis

The implementation of mobile and mounting solutions for a multi-camera rig in live recordings of open heart surgeries will significantly enhance surgical education, quality assurance, and cost-effectiveness compared to traditional stationary camera setups.

This hypothesis suggests that the utilization of mobile and mounting solutions for a multi-camera rig will lead to improved educational outcomes by providing a more immersive and comprehensive learning experience for medical professionals. Additionally, it posits that the ability to capture multiple angles and perspectives will enhance the quality assurance process, enabling surgical teams to identify areas for improvement and refine their techniques. Finally, it proposes that the adoption of these solutions will result in cost savings through telemedicine and virtual collaboration, reducing healthcare expenses associated with expert consultations and training programs.

### C. Agenda

This paper investigates the potential benefits and advancements of mobile and mounting solutions for a multi-camera rig in live recordings of open heart surgeries. It reviews existing research, explores the development and implementation of these solutions, examines their educational and quality assurance advantages, and investigates their cost-effectiveness. Additionally, the paper outlines our intention to produce one of these rigs ourselves, contributing to the ongoing research and development in this field. Finally, it presents a vision for the future, highlighting the potential impact of these technologies on global collaboration and improved patient care.

## II. Method

The development of the mobile and mounting solution for the multi-camera rig involved a comprehensive and iterative process that encompassed various stages, including an observational study, discussions with surgeons, design and modeling, measurements, collaboration with experts, and the application of design methods. The detailed methodology employed in each stage is outlined below.

### A. Observational Study

To gain a thorough understanding of the operating room layout and spatial configuration, an observational study was conducted during an open heart surgery. This involved being present in the operating room, carefully observing the arrangement of equipment, machines, and personnel. By employing ethnographic research methods, such as participant observation and contextual inquiry, valuable insights were obtained regarding the physical environment, workflow, and potential challenges faced by the surgical team. These observations served as a foundation for subsequent design considerations and informed decisions related to the rig's mobility and placement.

### B. Discussions with Surgeons

In order to ascertain the specific requirements and preferences of the surgical team, detailed discussions were held with the surgeons, especially with our supervisor Kiet Tran, a pediatric heart surgeon at Skåne University Hospital. These interactions allowed for an in-depth exploration of their needs, concerns, and constraints associated with the implementation of a multi-camera rig. To facilitate these discussions, design thinking methods, such as empathetic listening and user-centered design, were employed. By actively engaging with the surgeons and encouraging their input, a collaborative approach was fostered, enabling us to understand the surgeons' perspectives and incorporate their expertise into the solution.

### C. Design and Modeling

To translate the conceptual design into tangible representations, computer-aided design (CAD) software, specifically Fusion 360, was utilized. This software facilitated the creation of detailed 2D drawings and 3D models of the multi-camera rig. By employing iterative design methods, such as rapid prototyping and user feedback loops, we were able to visualize and evaluate various design iterations. The 3D models allowed for testing of the rig's functionality, ergonomics, and integration with existing equipment, and as an aid for discussion regarding the next move in the process. This iterative design approach enabled refinements and modifications based on input from the surgical team, ensuring a user-centered and optimized design.

### D. Measurements

Accurate measurements within the operating room were crucial for ensuring that the multi-camera rig would fit seamlessly into the available space. Several visits were made to the operating room, during which extensive measurements were taken using digital calipers. These measurements included the dimensions of the designated areas, distances between equipment, and clearances required for unobstructed movement. By employing scientific measurement techniques, such as digital calipers, we ensured the accuracy and reliability of the collected data. These measurements served as a basis to make informed decisions and optimize the rig's dimensions and spatial requirements.

### E. Collaboration with ProSwede Invest AB

To augment the development process and benefit from specialized expertise, collaboration was established with ProSwede Invest AB, a family-owned business specialized in industrial assembly, disassembly, machine moving, machine construction, and manufacturing . In-depth consultations were conducted with the experts at ProSwede, who offered valuable insights into the physical feasibility of the design. Their experience and knowledge assisted in assessing the practicality of the proposed design, identifying potential obstacles, and recommending suitable materials. This collaboration allowed for the application of design expertise and manufacturing considerations, ensuring that the final product would meet the necessary safety, durability, and functional requirements.

### F. Modification of Mounting Solution

Initially, a trolley-based approach was considered for the rig's arm, allowing for easy maneuverability in and out of the operating room. However, after careful evaluation and further discussions with the surgical team, an alternative solution was adopted. Applying the principles of human factors engineering and usability testing, it was decided that the best way to mount the multi-camera rig was by replacing one of the ceiling-mounted surgical lamps with our camera rig. Therefore, the arm from one of the operation lamps was repurposed to mount the camera rig, removing the need of an additional trolley. This modification provided greater stability, flexibility, and improved utilization of the available space within the operating room. The decision to utilize the existing ceiling-mounted arm was made after considering factors such as ergonomics, ease of use, and the minimization of potential disruptions to the surgical workflow. By leveraging design methods such as concept iteration and user testing, we ensured that the chosen mounting solution aligned with the needs and preferences of the surgical team, while also maximizing efficiency and spatial optimization.

### G. Design Methods – An Overview

Throughout the development process, design methods played a critical role in guiding the decision-making and problem-solving processes. The observational study and discussions with surgeons facilitated an empathetic understanding of user needs, which in turn informed the design concepts. By employing CAD software and rapid prototyping, we were able to visualize and refine the rig's design iteratively, incorporating user feedback to enhance its functionality and usability. The utilization of precise measurements and scientific measurement techniques ensured that the rig would seamlessly integrate within the limited space of the operating room. Collaborating with experts from ProSwede Invest AB provided valuable insights into material selection, manufacturing considerations, and practical feasibility.

The application of design methods not only facilitated the development of a mobile and mounting solution for the multi-camera rig but also ensured that the final design was tailored to the specific needs of the surgical team and the constraints of the operating room environment. The integration of user-centered design principles, iterative prototyping, and collaboration with domain experts resulted in a solution that not only met functional requirements but also considered ergonomic factors, usability, and practical implementation.

### H. Summary

In summary, the methodology employed in the development of the mobile and mounting solution for the multi-camera rig encompassed various design methods, including observational studies, discussions with surgeons, CAD modeling, precise measurements, and collaboration with industry experts. By integrating these design methods into the development process, a user-centered and optimized solution was achieved, addressing the specific requirements of the surgical team and the constraints of the operating room environment.

## III. Results

After several months of iterative design work, we developed a fully functional mobile mounting solution for a multi-camera rig allowing for live recordings of open heart surgery. The solution consists of two main components: a camera rig bearing a seven-camera system that is permanently mounted to a ceiling-arm in the operating room (a ceiling-arm that priorly held an operating lamp) and a supporting arm that is fastened to the operating table using a truss. Due to the comprehensive and iterative nature of the design process, numerous conceptual

designs were drafted before ultimately reaching a design ready to be produced as a physical prototype. With the aid of ProSwede Invest AB, a fully functional prototype, consisting of the seven-camera rig mounted to a ceiling arm as well as the supporting arm, is current being manufactured to be used at the Children's Heart Center of Skåne University Hospital. Although the final product is yet to be finished and mounted in the operating room at BUS, we have tested the viability of the entire system by using the temporary rig (that is currently being used) and making sure that the ceiling arm would follow the motions of the operating room table. The ceiling arm was able to follow the motions of the operating table and without any difficulties when tilted in all four directions and also when the table was raised or lowered. Therefore, we are convinced that the final product will be fully functional once finished and installed in the operating room.

The camera rig (Figure 1) consists of six cameras positioned in a hexagonal shape with one camera directly in the middle of the hexagon which are mounted on a lightweight aluminum rig. The hexagonal shape of the camera positioning was one of the requirements from our supervisor and is important in order for the cameras to maintain optimal visibility during each surgical procedure. The aluminum rig provides both a mounting surface for each camera as well as enveloping the cameras, in order to provide both protection and support while maintaining the camera's correct position relative to one another.

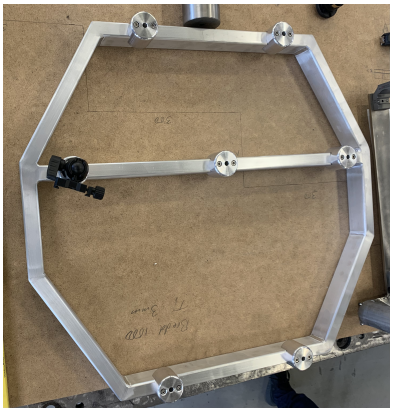

Figure 1. Camera rig with attachments for seven cameras in a hexagonal shape.

The supporting arm (see Figure 2) consists of a horizontal arm attaching to the camera rig, a vertical arm connecting the horizontal arm to the truss, and a truss attaching to the underside of the operating table. The function of the supporting arm is to ensure that the cameras maintain the same relative position to the operating table even when the operating table is lowered or raised, tilted, and/or rotated.

At the beginning of the project, while the trolley-based approach was still part of the plan, we focused mainly on the design for the truss attaching to the underside of the operating table and the supporting arm reaching from the truss up to the camera rig. The 3D models of these two components (see Figure 2) were designed based on the extensive measurements taken from the operating room and with a focus on minimally

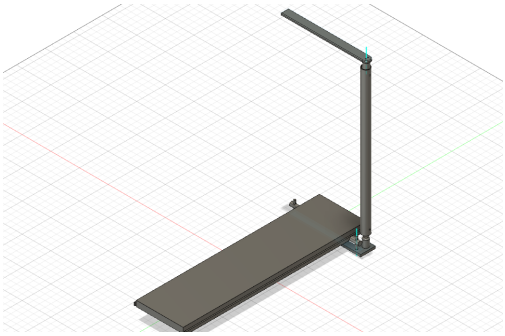

Figure 2. Support arm with attaching mechanism from Fusion360 design.

disrupting the surgical workflow. Our first physical prototype that was manufactured at ProSwede Invest AB consisted of these two components and was tested for fit on operating tables at BUS in Lund (see Figure 3).

Figure 3. Supporting arm physical prototype attached to an operating table at BUS.

The next step in our process was designing the camera rig. This proved to be quite difficult and required several iterations partially due to the rigorous restrictions in terms of the available space and optimizing the camera rig to be tailored for the operating room environment. Also, the positioning of the seven cameras was required to be in a hexagonal shape with a camera at each corner and one directly in the center of the hexagon. Ultimately, we landed on a design consisting of an outer protective wall on which the cameras could be attached using camera mounts (see Figure 4). This outer wall is made up of hollow rectangular aluminum tubing to keep the rig lightweight and durable. The edges of this tubing were also rounded to allow for ease of use without any unnecessary risk of injury. The camera mounts were pre-ordered and the platforms where they attach were manufactured as separate parts to be welded onto the upper side of the camera rig.

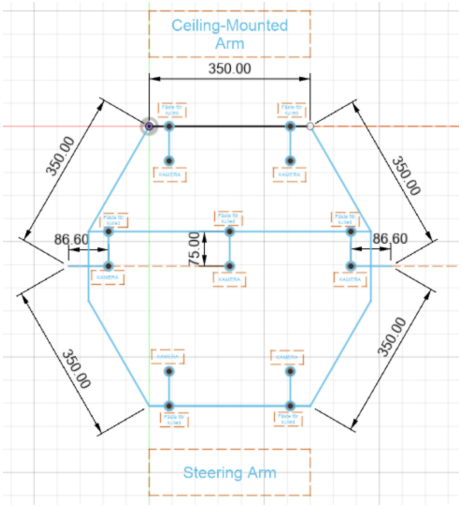


Figure 4. Fusion 360 design of the camera rig layout. Lengths are displayed in millimeters [mm]. Text boxes named "Ceiling-Mounted Arm" and "Steering Arm" indicates where these arm are going to be attached to the rig.

The entire camera rig is to be permanently installed in the operating room utilizing one of the already existing ceiling-arms that has been reconstructed to support the camera rig contrary to the surgical lamp it was carrying previously. When the multi-camera system is to be used, the camera rig is connected to the supporting arm from the operating table as well as ensuring that the cameras maintain the same position relative to the operating table even if the latter is repositioned.

## IV. Discussion

The development and implementation of the multi-camera rig for live recordings of open heart surgery have introduced the possibility of significant advancements in surgical education and training. In this section, we will discuss the implications of our findings, address the limitations of the rig, and explore potential avenues for future research.

One of the key benefits of the multi-camera rig is its ability to provide an immersive educational experience for medical students and surgeons. By capturing different angles and perspectives during surgery, the rig enhances knowledge transfer and allows for a more comprehensive understanding of surgical procedures. This can lead to improved surgical skills, increased confidence, and better patient outcomes. The real-time streaming capabilities of the rig also address the need for remote learning, making it especially valuable during situations such as the COVID-19 pandemic.

The utilization of lightweight aluminum in the rig's construction offers several advantages. Firstly, it ensures portability and ease of maneuverability within the operating room. Secondly, it reduces the strain on the ceiling-mounted arm, ensuring its stability and longevity. Additionally, the sustainable aspect of aluminum aligns with our commitment to environmental responsibility.

While the multi-camera rig has demonstrated significant potential, there are certain limitations that need to be addressed. One such limitation is the need for a robust data management system. The rig generates a vast amount of data during live recordings, requiring efficient storage, organization, and retrieval mechanisms. Future research should focus on developing effective data management solutions to optimize the usability and accessibility of recorded surgical footage.

Furthermore, the rig's design and aesthetics can be further refined. Although functionality has been prioritized, enhancing the rig's visual appeal can contribute to its seamless integration into the operating room environment. Incorporating user feedback can result in a more polished and visually pleasing rig, promoting user acceptance and satisfaction.

In terms of future research, the multi-camera rig opens up numerous possibilities. Exploring the integration of advanced imaging technologies, such as three-dimensional (3D) and virtual reality (VR), can enhance the immersive experience and provide more detailed insights during surgical procedures. Additionally, the incorporation of real-time collaboration tools and artificial intelligence applications holds promise for further enhancing surgical education and decision-making processes during the surgery itself.

In conclusion, the multi-camera rig for live recordings of open heart surgery represents a significant step forward in surgical work, education, and training. Its immersive educational experience, lightweight aluminum construction, and potential for future advancements highlight its potential impact. By addressing the limitations, refining the design, and exploring new technologies, the rig can continue to evolve and shape the future of surgical education, ultimately benefiting medical professionals and improving patient care.

### A. Sustainable Development

In recent years, sustainable development has emerged as a crucial aspect in the design and implementation of medical technologies and healthcare practices. The development of the multi-camera rig for open heart surgery also took into account various sustainability considerations, aiming to minimize environmental impact and promote long-term resource efficiency. The following factors were considered during the design and production of the rig:

**a. Material Selection:** Conscious efforts were made to select materials that are sustainable, durable, and have a minimal ecological footprint. After careful consideration, lightweight aluminum was chosen as the primary material for constructing the multi-camera rig. Aluminum offers several sustainability advantages, including its lightweight nature, high strength-to-weight ratio, and recyclability. Its low energy requirements during the production phase and ability to be recycled at the end of its lifecycle contribute to reduced environmental impact compared to alternative materials such as cast iron or hard plastic. By opting for lightweight aluminum, the rig promotes resource efficiency and supports sustainable material choices in medical device manufacturing.

**b. Utilization of Existing Infrastructure:** In line with sustainable development principles, we made a conscious decision to leverage the existing infrastructure in the operating room. Instead of introducing additional equipment, the rig was integrated with the already existing ceiling-mounted arm. This approach minimized the need for new installations and

reduced material consumption, resulting in resource savings and a reduced environmental footprint.

**c. Resource Optimization:** Efforts were made to optimize resource utilization during the design and production of the rig. This included minimizing material waste, optimizing component integration, and maximizing the longevity of the rig. By using lightweight aluminum and integrating the rig with the existing ceiling arm, the overall resource consumption was reduced. Additionally, the recyclability of aluminum ensures that at the end of its useful life, the material can be recovered and reused, further contributing to sustainable resource management.

**d. Extended Use and Adaptability:** The multi-camera rig was designed with the aim of extended use and adaptability. Its modular design allows for future upgrades, modifications, and integration with emerging technologies. By enabling adaptability, the rig reduces the need for frequent replacements and contributes to a more sustainable approach in the long term.

By considering sustainable development principles and integrating environmentally conscious approaches throughout the design and production process, the multi-camera rig for open heart surgery aims to minimize its environmental impact, promote resource efficiency, and contribute to a more sustainable healthcare system. The use of lightweight aluminum as the primary construction material and the utilization of the existing ceiling arm in the operating room demonstrate a commitment to sustainable material choices and infrastructure optimization, highlighting the rig's contribution to reducing resource consumption and environmental burdens associated with traditional construction materials.

It is important to note that while efforts were made to incorporate sustainability considerations, ongoing monitoring and evaluation are necessary to identify further opportunities for improvement and to ensure the rig's continued alignment with sustainable development principles.

### *B. Ethical Considerations*

The development and implementation of medical technologies, such as the multi-camera rig for open heart surgery, raise important ethical considerations. These considerations revolve around ensuring equitable access to healthcare, respecting patient autonomy, and promoting patient welfare. The following ethical aspects were taken into account during the development of the rig:

**a. Equal Access to Healthcare:** One fundamental ethical principle is the right to the same level of healthcare for all individuals. The introduction of the multi-camera rig aims to enhance surgical education and training, ultimately improving patient outcomes. By providing detailed and immersive live recordings of open heart surgeries, the rig can bridge the educational gap, allowing medical professionals, regardless of geographical location or institutional resources, to access valuable educational material. This promotes equal opportunities for professional development, ultimately benefiting patients around the world.

**b. Respect for Patient Autonomy:** Respecting patient autonomy is paramount in the design and use of medical technologies. The recording and use of live surgical footage raise concerns about patient privacy and informed consent. Strict adherence to ethical guidelines and obtaining informed consent from patients is crucial to ensure their autonomy and protect their privacy rights. Patients must have the opportunity to understand and provide consent for their participation in live recordings, taking into consideration the potential benefits, risks, and confidentiality aspects associated with the use of the multi-camera rig.

**c. Patient Welfare and Safety:** Patient welfare and safety are of utmost importance in the development and implementation of any medical technology. The design and use of the multi-camera rig prioritize patient welfare by ensuring that the recording process does not interfere with the surgical procedure or compromise patient safety. The rig is carefully positioned to minimize any potential disruption to the surgical team's workflow, while maintaining a safe and sterile environment. Additionally, strict protocols for data management and storage are implemented to safeguard patient privacy and confidentiality.

By addressing these ethical considerations, the development and use of the multi-camera rig for open heart surgery uphold principles of equal access to healthcare, patient autonomy, and patient welfare. The ethical framework surrounding the rig underscores the commitment to responsible innovation and the promotion of ethical practices in healthcare technology.

It is crucial to emphasize that ethical considerations are an ongoing responsibility. Regular evaluations, ethical reviews, and open dialogues with stakeholders are necessary to ensure that the use of the multi-camera rig remains ethically sound, aligns with evolving ethical standards, and safeguards the rights and well-being of patients and healthcare professionals.

### *C. Future Improvements and Development*

The development of the multi-camera rig for open heart surgery represents an important step forward in enhancing surgical education and training. It is important to note that the rig currently in use is not the final prototype, and there is ongoing potential for further improvements and refinements. The following areas offer avenues for future development:

**a. Aesthetics and Design Refinement:** While functionality and performance are crucial, aesthetics and design refinement play a significant role in the acceptance and integration of the multi-camera rig in the operating room environment. Future iterations can focus on creating a more polished and visually appealing design that aligns seamlessly with the existing operating room infrastructure. This includes exploring options for streamlined cable management, improved ergonomics, and a more finished look to enhance user satisfaction.

**b. Integration with Operating Room Systems:** Further integration of the multi-camera rig with existing operating room systems can enhance its functionality and usability. Collaborating with surgical teams and technical experts can help identify opportunities for seamless integration with surgical information systems and image-guided surgical navigation systems. Such integration would enable real-time data exchange, improve workflow efficiency, and provide a more comprehensive surgical environment.

**c. Miniaturization and Portability:** Advancements in miniaturization and portability can make the rig more versatile and adaptable for various surgical settings. Exploring compact and lightweight components, wireless transmission technologies, and portable power solutions can facilitate easy deployment of the rig in different operating rooms or even remote surgical locations. This would expand the accessibility of live surgical recordings and educational resources to a broader audience.

**d. Usability and User Experience Enhancements:** Continued efforts should be directed towards optimizing the rig's usability and user experience. Feedback from surgical teams and end-users should inform iterative improvements, addressing aspects such as functionality and customizable settings. User-centric design approaches can lead to enhanced user satisfaction, increased efficiency, and seamless integration into the surgical workflow.

By embracing future improvements and directions, the multi-camera rig for open heart surgery can continue to evolve and refine its design, functionality, and overall user experience. It is through ongoing innovation, collaboration, and feedback from medical personnel that we can create a more sophisticated and visually appealing rig, further enhancing surgical education, training, and patient outcomes.

## V. Conclusion

The multi-camera rig for open heart surgery could come to represent a significant advancement in surgical education, preparation, and evaluation. Positioning six cameras in a hexagonal shape with one directly in the center on an easily adaptable multi-camera rig ensures maximum visibility of the operating surface at all times. Having the camera-rig mounted to the ceiling in an operating room allows for simple storage and easy accessibility for each surgical procedure, while the steering-arm can quickly be installed to the operating table and allows the cameras to maintain the same positioning relative to the operating table at all times.

Future improvements will focus on refining the rig's aesthetics and design, ensuring a more visually appealing appearance. Collaboration and innovation will drive ongoing enhancements and optimize the multi-camera rig's adaptability to other surgical environments, benefiting both patients and medical professionals.

## VI. Afterword

We would like to express our sincere gratitude to the following individuals who have provided invaluable support and assistance throughout the project:

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Lastly, both authors have contributed equally to this project and have been involved in every step of the process, from conceptualization to implementation to the writing of this paper.

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