-Worksheets-

Worksheets

VGIS-7
GROUP 743

Aalborg University

Rules

Designing Rules for a VR Environment

To ensure realism and to estimate functionality of the virtual reality simulation a set of rules for the system should be drawn. The core rules can be separated into three primary groups; the system, the users, and the virtual equipment. However, these rules are set prior to implementation but are based on observations made in the training room as well as interviews with Jane Petersson. The mindmap of these rules is shown in Figure Figure 1.

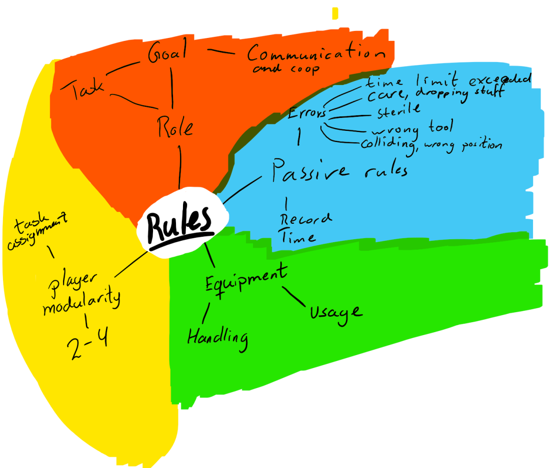

Figure 1: Mindmap

The System

The rules set for the system can be considered passive. These rules primarily exist to accurately recreate the environment and ensure the proper functionality of the surgical equipment. These rules also track any errors that might be done by the users, such as poor positioning of the robot arms or incorrect tool placement.

The User

The users in the scene should be designated a specific role which entails different tasks, but they should not be limited by that role. Completing a task as a group, rather than multiple individuals should be the primary focus for the users, since communication is vital to the success of the simulation.

The Equipment

The equipment's rules should primarily focus on their specific use and how they should be handled by the users. Furthermore it should also include how the equipment should respond to certain user actions or other objects within the scene.

Training Session

Purpose

The purpose of the interview is to gain understanding of how nurses and surgeons are training to operate a da Vinci robot and perform (RAMIS).

Method

We performed a semi-structured interview with one of the nurses who train students, Jane Petersson and a surgeon, Johan Poulsen, at MUIC.

Results

The training of the students consists of boht a theoretical course and a practical session. During the theoretical course, students learn about the equipment and how to operate it. In the practical session, a group of four students perform an operation on a live pig. During the session, students change roles and perform a variety of tasks. An instructor is giving instructions about their have to do. The purpose of the training is for the students to get familiar with the robot and perform practical tasks while focusing on communication between team members. Before the surgery, the instructor usually sabotages parts of the procedure to simulate unexpected situation for the students. The team consists of a surgeon, first assistant and nurses. The surgeon operates the robot while the first assistant changes tools and assists with tasks that require work inside the patient's body. The nurses prepare tools for the first assistant during the procedure and sanitise the robot before the surgery.

Conclusion

The interview has given an insight into the training situation of the nurses working around and with the robot.

Second Interview

Purpose

The purpose of the interview was to understand how nurses and surgeons train to operate a da Vinci robot and perform (RAMIS).

Method

We performed a semi-structured interview with one of the nurses who train students, Jane Petersson, at MUIC.

Results

One of the most important things during surgery and training is the emergency handling, however this requires extensive knowledge of the robot and tools. Another very important task is the placement of the robot arms because collisions during surgery can be very dangerous. Sometimes the surgeons adjust the arms manually.

In general, the training is for hands on experience with the robot and individual instruments, in preparation for a real surgery.

The team training consists of:

- First assistant nurse - Sterile, assists the surgeon inside the patient's body.
- Scrub nurse - Sterile, prepare unpacked tools for the first assistant nurse.
- Circulating nurse - Not sterile, unpacks tools, and can go outside the sterile area.

During training, on the first day Jane Petersson starts by talking and showing how tasks are done, students observe. On the second day, students are expected to do most of the tasks themselves. At the end of the second day, Jane Petersson sabotages some of the equipment and the students have to find and fix it. Any mistakes done by the students are used for learning purpose. At the beginning of the training, Jane Petersson makes most of the decisions, however later the surgeon is expected to take the lead.

Conclusion

Observing Operation

Purpose

The purpose of this field study is to observe the context to be simulated. This is done to asses of what must be included in the design.

Method

A contextual inquiry is conducted to collect information resulting in different analysis models. To analyse and retrieve information in the matter the main method used is a contextual inquiry. This includes the different analysing models and interviews. We observed a robot assisted surgery at Aalborg University Hospital performed on a living human being.

The observation team took both pictures, notes, and some video from the operation. These illustrate the tasks and teamwork necessary to perform such an operation and were used to create different models used in contextual inquiries. The models used are; a physical model showing the layout of the room, a sequence model to clarify the work flow, and an artefact model showing objects used during the procedure.

Results

The physical model shows the layout of the operation room and the personnel's workspaces. The figure includes doors and their movement as well as other objects. The layout is shown in Figure 9.

The physical enables the development and design of the room when creating the simulation.

The sequence model is based on Jane Petersson's worksheet used in team training at MUIC. The sequence model is shown in Figure 10.

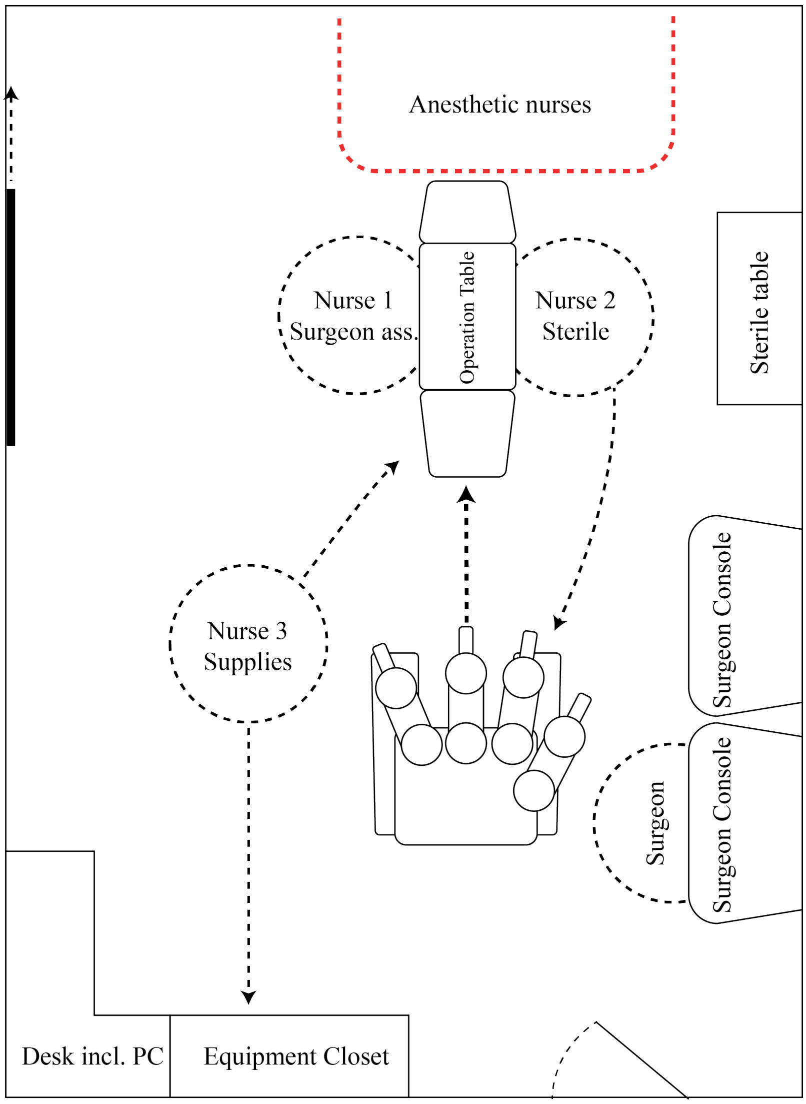

Figure 2: The phyiscal model showing the layout of the operation room

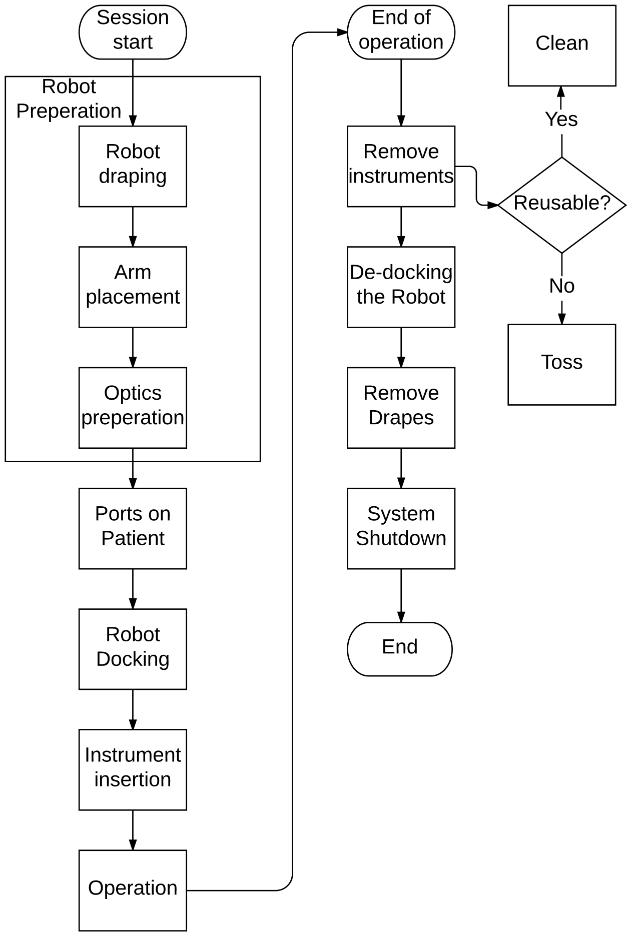

Figure 3: Flowchart of the sequence model showing how the operation preparation and debrief is carried out

The sequence model describes the actions necessary to both start the operation and to end it. This enables the design of the tasks which should be included in the simulation and their order of appearance to the user. The model shown is for an operation without any complications, which could lead to de-docking of the robot in an emergency.

The Artefact models are shown in figures 11, 12, 13, 14, and 15. These are created from pictures taken during the observation. Figure 11 shows the plastic drapes used to cover the arms of the robot sterilising it. Figure 12 shows the endoscopic camera during calibration. Figure 13 shows the endoscopic camera up close. Figure 14 shows one of the ports used to insert the tools into the patient. Figure 15 shows the tools used with the robot.

Figure 4: The drapes used to cover the arms of the robot, sterilising them

Figure 5: The camera used with the robot and a calibration tool

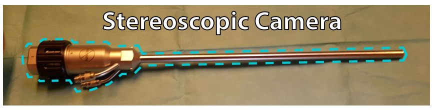

Figure 6: The endoscopic camera up close

Figure 7: One of the ports used to insert the tools in the patient

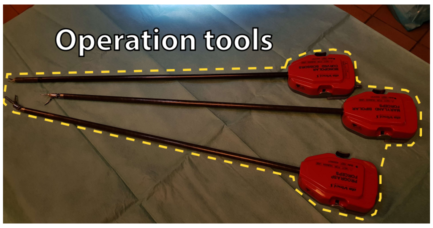

Figure 8: The tools used with the robot

Conclusion

The physical model provides both information regarding the physical layout of the simulation to be developed, as well as a limitation of the implementable of the scenarios.

The sequence model outlines the entire scenario from which tasks must be implemented, as well as providing an overview of important tasks to include in the simulation.

The artefact model also shows which tools are important for the simulation to look realistic.

Notes Taken During the Observation

- If you are not sterile, you have to stand at least one meter from sterile objects.
- The tables covered in green paper blankets are sterile.
- When preparing tools and unpacking, two nurses works together. One non-sterile nurse unpacks while the other, sterile, nurse grabs and places the tools on the sterile table.
- The sterile nurse sterilises the robot.
- When the patient enters the room he is firstly laid down on the operating table and then prepared for surgery.
- The stereoscopic camera is wrapped separately from the robot and other tools.
- When all sterile tools are placed, the sterile table is covered.
- The camera is calibrated by the sterile nurse. This is done using different kinds of end pieces and rotating them around scopes.
- The arms of the robot must be placed in a specific order. This is to avoid any kind of collision of the arms. Furthermore, the placement of the arms is as important as the order. This is done before the robot is docked.
- Before the robot is docked, the nurses taking part in the operation are sterilising.
- When the robot is docked the arms are once again placed, this time around the ports inserted on the patient.
- A time out is taken before any cutting securing everyone and everything is ready and in place.
- The first cut done on the patient is to expand his stomach using air, easing the operation as this will yield more space.
- Before docking the camera on the robot it is used hand held to insert the other instruments and afterwards docked on the dedicated robot arm.
- When the camera is docked the robot arms are placed as far apart as possible. This is done to avoid collision.
- Each arm has three buttons enabling arm movement in two different ways.
- Cleaning of the optics is done several times during the operation. it may even be changed for another if it is too dirty.
- Communication during operation is somewhat an issue as the original speaker system made for this kind of surgery is broken. Instead, a small speaker and

bad microphone is used.

Field Studies

Purpose

The purpose of the studies was to understand how nurses and surgeons train to operate a da Vinci robot and perform robot assisted minimal invasive surgery (RAMIS), as well as to asses what must be included in an surgery scenario. Finally an evaluation of the finished product created is conducted on the basis of these interviews.

Method

We observed a training session at MIUC followed by a semi-structured interview with Jane Petersson and Johan Poulsen to get an understanding of RAMIS and how surgeons practise. Furthermore, we performed a semi-structured interview with first assistant nurse Jane Petersson who is in charge of training nurses to handle the robot and how to act in a team environment.

A contextual inquiry is conducted to collect information resulting in different analysis models. To analyse and retrieve information in the matter the main method used is a contextual inquiry. This includes the different analysing models and interviews. We observed a robot assisted surgery at Aalborg University Hospital performed on a living human being.

The observation team took both pictures, notes, and some video from the operation. These illustrate the tasks and teamwork necessary to perform such an operation and were used to create different models used in contextual inquiries. The models used are; a physical model showing the layout of the room, a sequence model to clarify the work flow, and an artefact model showing objects used during the procedure.

To evaluate the simulation created, an expert review was conducted with both Jane Petersson and Johan Poulsen. They were both introduced to the simulation and virtual reality and were able to try the simulation. Afterwards a scripted interview was conducted. The script for this is shown in **??**.

Results

The results are split into three sections; one for the surgeon training at MIUC, one for the other interview with Jane Petersson regarding team training and the last for the expert review of the simulation.

Surgeon Training at MIUC

The training sessions at MIUC varies depending on the skill level of the participants. In cases with skilled participants, the students takes on the role as instructors to help guide during the training session. This is beneficial as the surgeon often will be in charge of during surgery.

During the interview, Jane Petersson explained that during team training a surgeon will operate the robot while making calls for the nurses in training to do. The individual tasks for the nurses depends on their current role and what they are studying to become. For instance, a first assistant nurse is the one who assists the surgeon inside of the patient. In general, the training focus highly on getting familiar with the robot and how it operates during surgery. One particular task is important for the nurses to learn - how to dock the robot. As stated by both Jane Petersson and Johan Poulsen, ensuring that the robot is rightfully docked is key to enable the surgeon full movability of the robot. Johan Poulsen also expressed the importance of sterility of staff and tools, however in a VR simulated environment errors can be made without it causing complications which is beneficial for the learning process.

.0.1 Interview with Jane Petersson

One of the most important things during surgery and training is the emergency handling, however this requires extensive knowledge of the robot and tools. Another very important task is the placement of the robot arms because collisions during surgery can be very dangerous. Sometimes the surgeons adjust the arms manually.

In general, the training is for hands on experience with the robot and individual instruments, in preparation for a real surgery.

The team training consists of:

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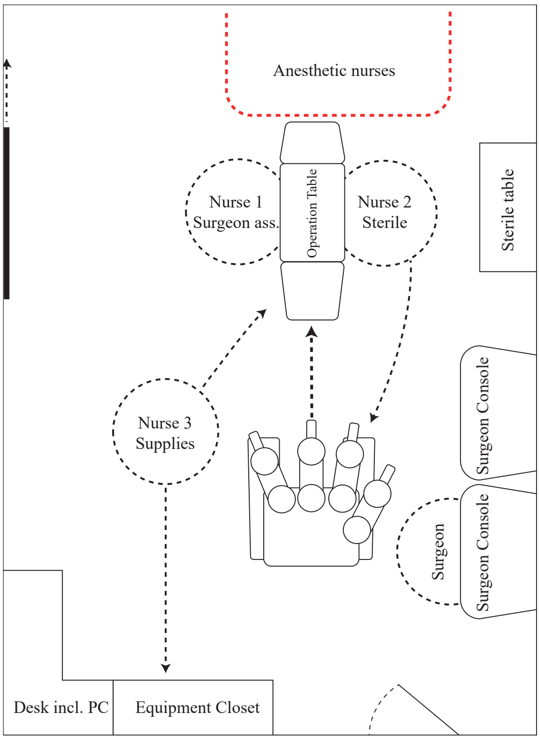
During training, on the first day Jane Petersson starts by talking and showing how tasks are done, students observe. On the second day, students are expected to do most of the tasks themselves. At the end of the second day, Jane Petersson sabotages some of the equipment and the students have to find and fix it. Any mistakes done by the students are used for learning purpose. At the beginning of the training, Jane Petersson makes most of the decisions, however later the surgeon is expected to take the lead.

.0.2 Contextual Inquiry

The physical model shows the layout of the operation room and the personnel's workspaces. The figure includes doors and their movement as well as other objects. The layout is shown in Figure 9.



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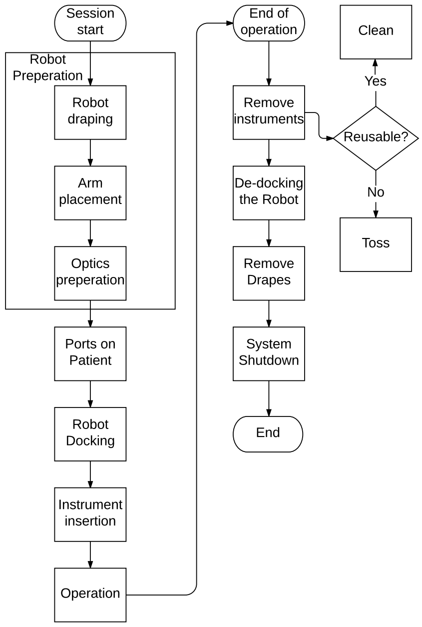

Figure 10: Flowchart of the sequence model showing how the operation preparation and debrief is carried out

The sequence model describes the actions necessary to both start the operation and to end it. This enables the design of the tasks which should be included in the simulation and their order of appearance to the user. The model shown is for an operation without any complications, which could lead to de-docking of the robot in an emergency.

The Artefact models are shown in figures 11, 12, 13, 14, and 15. These are created from pictures taken during the observation. Figure 11 shows the plastic drapes used to cover the arms of the robot sterilising it. Figure 12 shows the endoscopic camera during calibration. Figure 13 shows the endoscopic camera up close. Figure 14 shows one of the ports used to insert the tools into the patient. Figure 15 shows the tools used with the robot.

.0.3 Expert Review

Jane Petersson and Johan Poulsen were both able to test the system. The following interview revealed that the system at present was satisfactory at simulating the scenario, but was not comprehensive enough to warrant implementation with them.

Figure 11: The drapes used to cover the arms of the robot, sterilising them

Figure 12: The camera used with the robot and a calibration tool

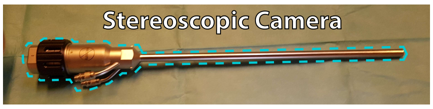

Figure 13: The endoscopic camera up close

Figure 14: One of the ports used to insert the tools in the patient

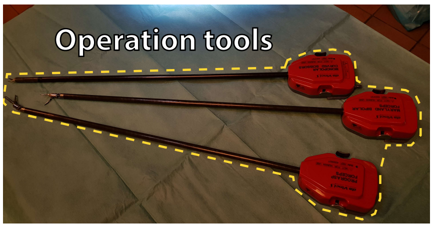

Figure 15: The tools used with the robot

They believed the interaction was sufficient, and that trainees didn't require additional features, however they both stated that several features should be available to the instructors, such as scene change and reset, interacting with procedures and progress, as well as changing the rules during play (for example by introducing emergencies).

One key point throughout the interview was realism. This was brought up many times during the interview, and the consensus was that the closer the simulation was to total realism, both with controls, models, and textures, the more it could replace or improve upon current training standards. This meant that, for example, the robot should have multiple end effectors to allow more realistic movement. The current da Vinci model has three control points and can rotate around itself which the simulated model does not. In addition, the robot itself should be moveable. Introducing tool ports would, together with the improved handling, allow for teaching docking and undocking in VR. Despite all this, draping the robot arms would need to be practiced at real facilities due to the need for accurate tactile feedback.

Johan Poulsen stated that there were limitations, but that systems such as this could be a must-have for the future of RAMIS. He talked about fully integrating the system with current simulators such as RAMIS console and anaesthetic nurse simulators. This could allow full surgery team training. As noted from the context study, Jane Petersson sabotages the robot setup during team training in order to train the nurses' and doctors' communication and emergency handling skills. Being able to control even more factors in virtual reality, such as patient fever, would allow for more detailed training of both nurses and surgeons. This concept could also be extended to include scenarios and scenario control. By being able to reset the scene and load a scenario where the setup is an appendectomy would also improve the utility of the system thereby having multiple scenarios to choose from.

Despite its limitations, the current version could be used to introduce medical students to RAMIS if realism was improved. Johan Poulsen also mentioned that, as there was no tactile feedback, the visuals in the scene had to become more realistic as the vision would overcompensate for the lack of tactile feedback.

Despite the current limitations both experts agreed that the controls of the system were intuitive and that the learning curve was appropriate for their level of expertise with VR. Observations also showed that they both learned to teleport, grab, and interact with the robot fast.

.1 Conclusion

The observations and interviews have given an insight as to how both the surgeons and the nurses train and work with the da Vinci Surgical System. Furthermore, critical procedures have been explained by Jane Petersson. These procedures are a must know as failures within these could prove critical or even fatal.

The concept of introducing VR training in established RAMIS training sessions seems feasible, however with some caveats. Currently, the system is too basic to warrant implementation at MIUC according to Johan Poulsen, but could serve other purposes such as introducing medical students to RAMIS. Experts stated that the system would require a high level of realism to accurately show the procedure and be useful in RAMIS training.

Problem Statement

Motivation

Robot assisted minimally invasive surgery (RAMIS) is used for many medical procedures. It allows for more precise surgery and lowers the risk of injury while reducing recovery time for patients [History of minimally invasive surgery]. Traditionally, the surgical performance has been measured in terms of surgeons' visuo-motor skills and dexterity, however a shift in the conceptualization of competencies is emerging in new literature (Safer Surgery book p 83). One of these competencies is teamwork in the operating theatre (source Hayley et al). A study concluded that 80% of incidents in anaesthesia related errors were preventable (Reported significant observations during anaesthesia: a prospective analysis over an 18-month period). Of these, 75% of these were due to human error.

Lingard et al studied communication in the operating theatre and found that 36% of errors affected the teamwork negatively (Communication failures in the operating room: an observational classification of recurrent types and effects). From this study, five key points of communication in the operating theatre were found: time, resources, roles, safety and sterility, and situation control.

To counter human errors, and to reduce critical events, simulation based training has become increasingly popular over the years (The simulated operating theatre: comprehensive training for surgical teams). This applies to multiple professional and high risk contexts such as aviation and surgery. As the goal of simulated training is to involve all members of the surgical staff and to enhance their performance, R. Aggarwal suggests that the method can also be applied to other procedures such as robot surgery. As robot surgery is also a high risk context, virtual simulations of high risk procedures is also beneficial. This paper will explore the possibilities of simulating a medical emergency during surgery training in Virtual Reality (VR) and document the effects on teamwork and performance.

Problem Statement

Based on the information above and focusing on the impact of recent Virtual Reality technology, this paper aims to answer the following problem statement:

"How can virtual reality be utilized to simulate an emergency situation during RAMIS training?"

Success Criteria

Up for discussion. What do you think Martin?

Suggestions:

- have a working prototype - have a way of measuring teamwork - have a way of measuring performance - have a procedure for testing the above and plan statistical test

Shaders

Purpose

The purpose was to create an outline that indicates to users whether the object they are nearing is interactable. The important objects in the scenario are the laparoscopic tools, the robot arms, and other items such as scissors and scalpels. Somehow indicating that items can be interacted with is important in VR and in many other graphical environments such as games.

Method

Two different outlines were created using different techniques; inverted normal meshes and post processing. Inverted normal meshes, or front face culling, are applied over the regular mesh and upscaled slightly. They are easy on GPUs compared to many post processing effects, but lack in customizability and accessibility during runtime. They also get increasingly visually disruptive when applied to detailed meshes. Post processing is usually computationally expensive compared to the previous method since they require at least an extra depth render, but they perform better in edge cases (such as overlapping), and are very customizable even during runtime. This was implemented using Unreal Engine's post processing stack, a custom depth render on important objects, and a global custom material. In the case of overlapping, for example when users grab the objects, inverted normal meshes work as any other mesh in that it renders to the depth buffer, whereas post-processing requires an extra check for depth at each position.

The post-processing effect was implemented using edge detection. This means that colour differences at edges are detected, and a linear interpolation from normal colours to a chosen outline colour decides which to render based on a parameter called edge angle falloff.

Results

Figure 16: Comparison between methods. Left: Post processing, line width 3. Right: Inverted normals mesh, upscaled 1.1

Figure 16 shows the two methods compared to each other. The inverted normal mesh is upscaled to 1.1 and uses black for both its main colour and its emission (meaning it is independent from light source blending). The post-processing effect uses texel width 3 and edge angle falloff -100 (which appears to only detect outer edges).

The post processing outline is a part of the mesh, whereas the inverted normals mesh extends over the regular mesh. The right side also shows some differences in line width, as well as some irregular lines around the eyes. On the left side, the lines being part of the monkey head mesh is also very obvious, as some of the detail is lost.

Conclusion

Based on these results, we implemented the post-processing effect on the interactable objects in the scene. These were easily accessible and customizable, and provided a consistent look on all objects and at all angles without creating new meshes. The problem with detail loss from the outlines extending into the mesh was not an issue since the effect only appeared once users were close enough to grab the objects.

3D Modelling and Animation

3D Modelling

The 3D model of the da Vinci robot was created in Autodesk 3DS Max. The robot needed to be modelled as realistic as possible and as such the program was chosen based on it's level of detail and built-in functions. However, due to the location and visitation possibilities of the da Vinci Si System it was not possible to capture every detail of the robot. As such, the robot is modelled partially from images taken, images on the internet, and memory. The robot was modelled with box modelling and was compared to a human model to ensure somewhat realistic sizes of the individual parts.

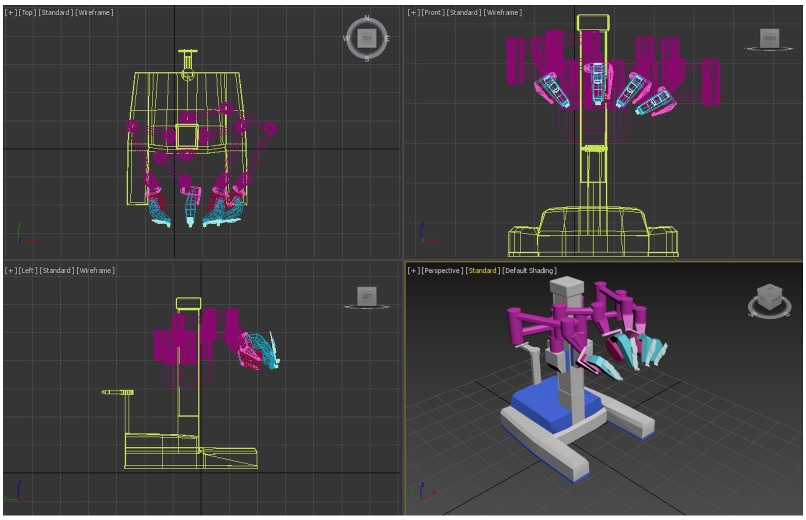

Figure 17: The robot shown in Max' default workspace separated into four perspective views

After modelling finished the model was imported into Autodesk Maya which allows for easier rigging and animation. Maya is a tool that is tailored to animation whereas 3DS Max is primarily for modelling. Rigging the model was done according to where the robot is capable of rotating in real life.

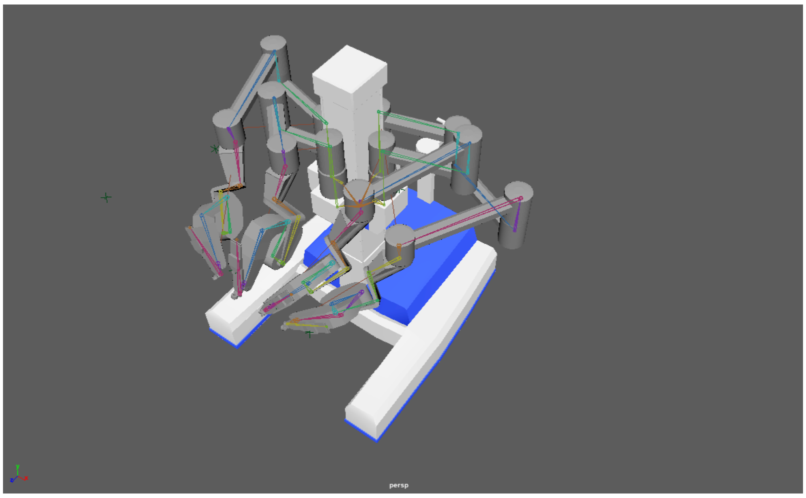

Figure 18: The robot shown in Maya's default workspace indicating bones

3D Animation

A 3D animation was created to ensure that realistic docking procedure could procede as a backup for the real-time interaction. In the case of using animation instead of interaction, a button would have to implemented in the scene to start the animation. As such, the robot would be in an initial "undocked" position and upon button press the robot would play the animation of docking. This animation could then be reverse to simulate undocking.

The animation was created in Autodesk Maya 2017, due to previous knowledge and its powerful animation tools. The robot had already been rigged in Maya for interaction in Unreal Engine 4, which allowed for quicker animation.

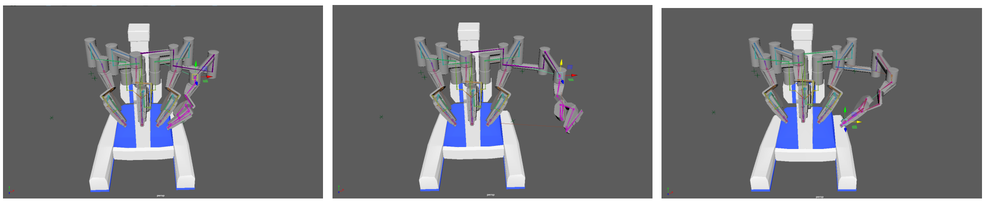

Figure 19: IK handles in Maya's workspace

FABRIK

Forwards and Backwards Reaching Inverse Kinematics (FABRIK) is an algorithm that efficiently solves inverse kinematics for a number of joints in a system. Being a heuristic model, FABRIK avoids solving rotational matrices as conventional IK solvers, and instead translate the joints to a point on a line. This results in low computational requirements and and therefore faster computational speeds. A table comparing FABRIK to other IK solvers is shown in Figure Figure 20.

Average results (over 20 runs) for a single kinematic chain with 10 joints.

	Reachable Target				Unreachable Target	
	Number of Iterations	Matlab exe. time (*sec*)	Time per iteration (in *msec*)	Iterations per second	Number of Iterations	Matlab exe. time (*sec*)
FABRIK	15.461	0.01328	0.86	1164	67.564	0.06207
CCD	26.308	0.12356	4.69	213	390.135	3.92869
Jacobian Transpose	1311.190	12.98947	9.90	101	6549.000	33.90473
Jacobian DLS	998.648	10.48051	10.49	95	2881.667	14.87918
Jacobian SVD-DLS	808.797	9.29652	11.50	87	2808.452	15.97591
FTL	21.125	0.02045	0.97	1033	22.325	0.02526
Triangulation	1.000	0.05747	57.47	21	1.000	0.06993

Figure 20: Comparisons of different IK solvers according to

The following section describes how FABRIK have been implemented and applied to the virtual da Vinci robot. It also describes the current problems with the algorithm and its implementation in Unreal Engine. The algorithm have been implemented according to Andreas Aristidou and Joan Lasenby [].

FABRIK is implemented in Unreal Engine's Animation Blueprint, but as this only allows to define preset animation sequences, it cannot be used to interact with in real-time. Standard Blueprint does not allow for bone or joint transformations and therefore a Poseable Mesh has to be created from the skeletal mesh of the robot in order to program bone behaviour.

FABRIK Algorithm Example

Figure **??** shows an example of a system consisting of four bones and an end effector. The goal of the algorithm is to get the outermost bone (P4) as close to the end effector (t) as possible and maintaining the original distance between each bone. The FABRIK algorithm starts by adding all bone lengths together to determine if the target is reachable or not. As FABRIK is a heuristic bone translation algorithm it starts at the end effector P4 and sets its position to the target's position as seen in Figure XX. The new heuristic joint is called P'4

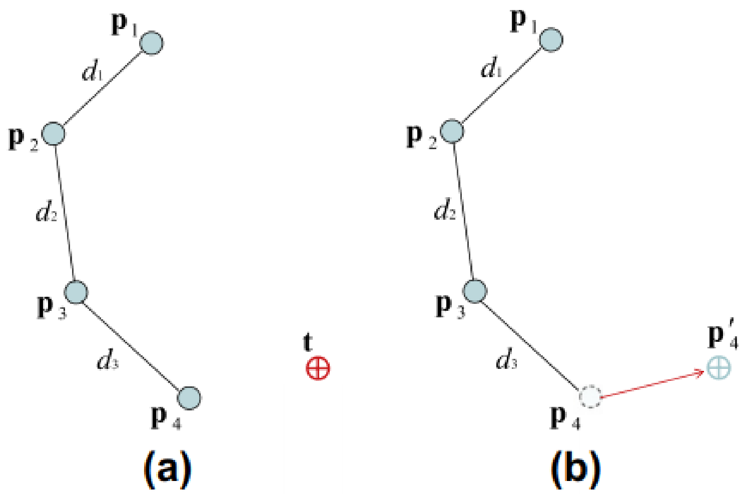

Figure 21: •

A line is then drawn from P'4 to P3, and since the original distance have to be maintained, P'3 is translated to somewhere on that line as seen in Figure **??**(c). The position on the line is calculated by

$P'3 = (\hat{P}3 - \hat{P}4) * d_3$

This procedure is then repeated for each bone in the system, creating a heuristic position for all joints, as seen in Figure XX. This results in the root bone(P1) being translated as well.

The root joint is then moved back to its initial position and the same process now repeats in the other direction (root to outer joint) as seen in Figure **??**.

This process is then repeated until the end effector hits the target or gets sufficiently close.

.0.1 Implementation in Unreal Engine

For implementation purposes, Unreal's Poseable Mesh blueprint was used to translate the bones toward the target. Below is a table of the variables used by the blueprint with a description of its use.

The code is split up in four main parts;

- BeginPlay

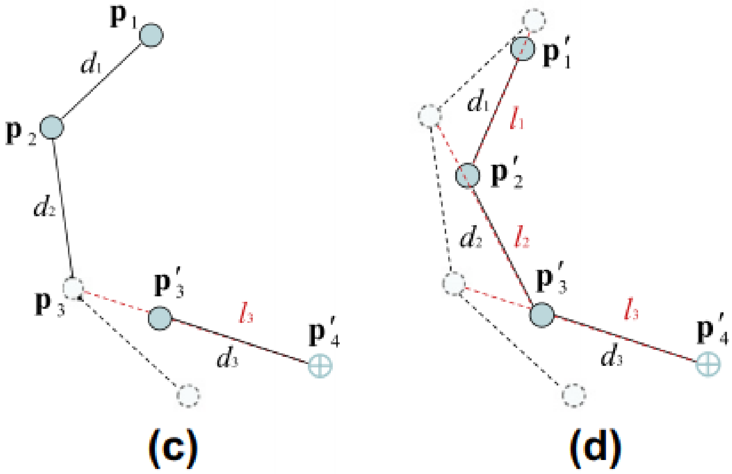

Figure 22: •

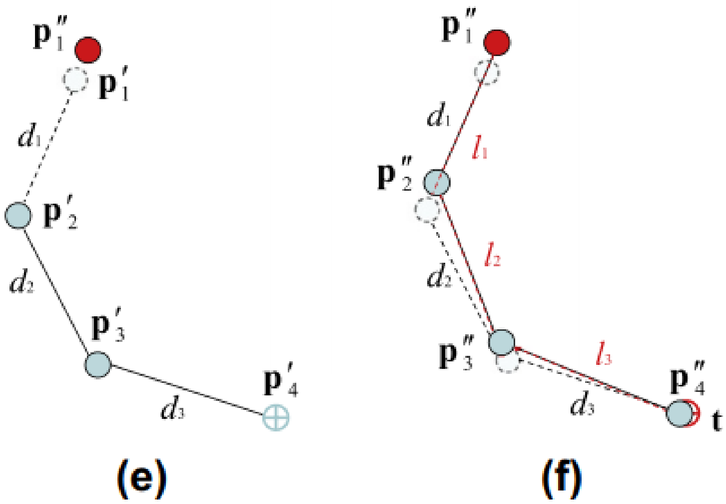

Figure 23: •

Table 1: My caption

Name of Variable	Type	Use
Arm1	Array of Bones	Contains all the bones of the robot arm. Used to re
BoneLocations	Array of Positions	Contains all the bones positions in world space. Used in the start to calculate the original distances between joints and updated later when new positio are calculated.
Lengths	Array of Bone Lengths	The array of bone lengths are constant and is need calculate heuristics.
Target	Object	The actual object that the end effector will try to r This is a red semi transparent cube. Used to set th effector's position to the target and to calculate pro
Origin1	Position	The root's original position. Used in the start of th part where the root's position is set to its original p

- OutOfReach
- Backwards (Heuristics)
- Forwards (Positioning joints)

BeginPlay initializes and calculates all of the variables in Table 1. OutOfReach determines if the target is out of reach and, if so, stretches all bones in the target's direction. Backwards handles the heuristics of the algorithm and the flow of this program can be seen in Figure 24. The Forwards then calculates the real position of the joint and sets the position of the joint in world space. The forwards look like the flow in Figure 24 the only difference being a positive for loop and the order in the "pos" calculation.

Results

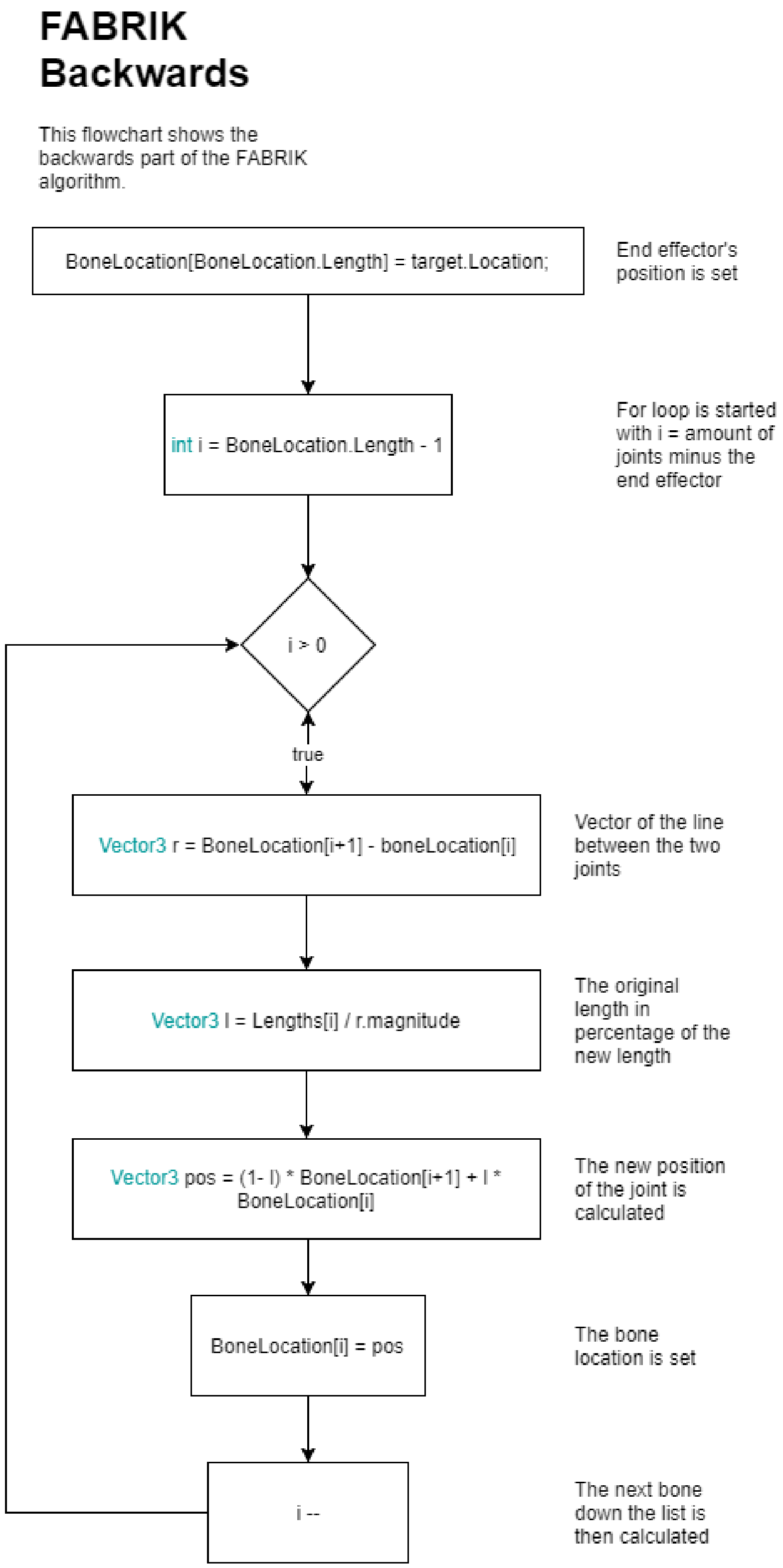

Figure 24: Caption here

Internal Test

Purpose

The purpose was to test the system used in the expert review, including hardware load and frame times. This was done to ensure a "smooth" (pls fix) test and to determine whether potential issues could be attributed to physical limitations. Since the review and system test were both performed over LAN, no latency testing was performed.

Methods

The test was performed at AAU's Audio-Visual Arena using the computers described in Table 2.

Two players and two observers were present. The players moved around in an introduction scene and in the final scene used in the system review. The observers recorded data using MSI Afterburner and Fraps to measure CPU and GPU load as well as framerate.

	Computer A	*Computer B*
CPU	Intel Core i7-4770	Intel Core i7-6700
GPU	Nvidia GTX 980	Nvidia GTX 980
RAM	16GB	16GB

Table 2: Specifications of the computers used

Results

The results from the hardware monitoring is shown below. The range indicates roughly 10 minutes of play.

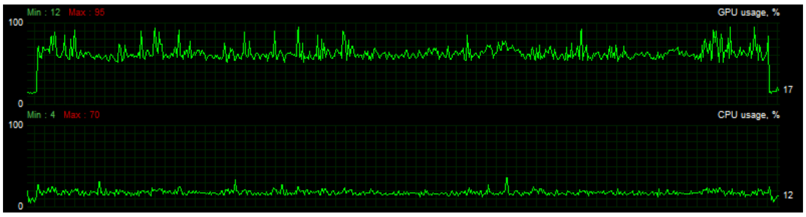

Figure 25: Hardware usage of Computer A

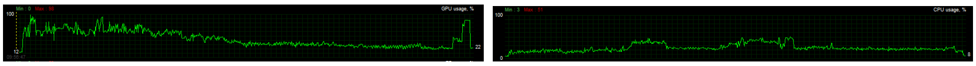

Figure 26: Hardware usage of Computer B

The results from recording framerate is shown below.

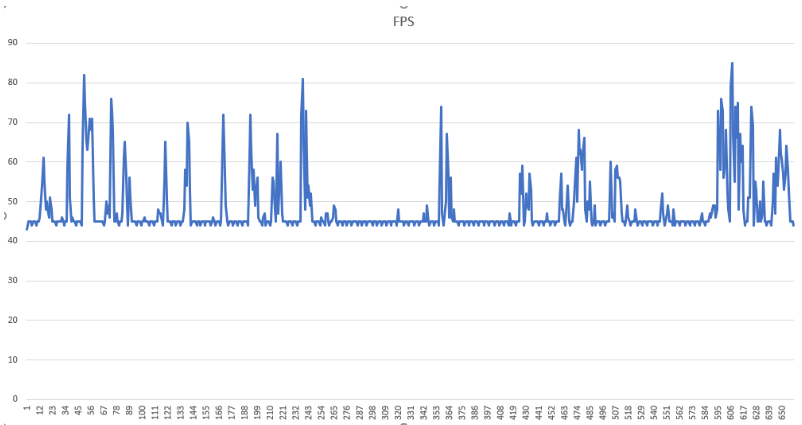

Figure 27: Results from recording framerate in Computer A

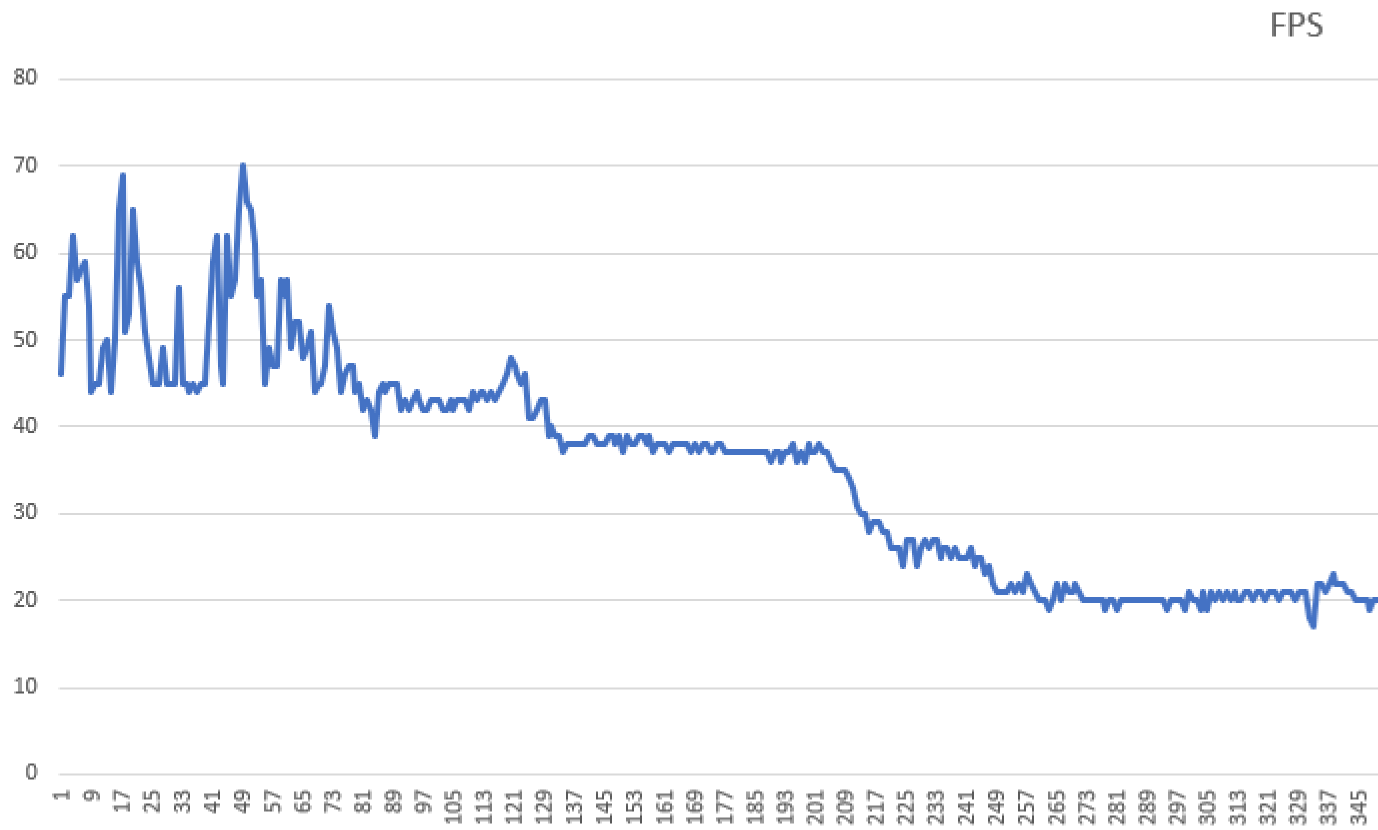

Figure 28: Results from recording framerate in Computer B

Conclusion

The framerate results show line at 45 frames per second, however monitoring in the same scene before beginning the recording showed a steady 90 frames per second. We hypothesize that the recording software is at fault, and cannot accurately record framerate in virtual reality applications. This was, however, the only possible solution since no native software can log it.

The results show a steady decline in framerate for the client computer. This was confirmed in several tests to be the case for any computer used as client, but does not seem to be caused by overheating. The client's GPU usage steadily drops while CPU usage seems to jump.

This may be the fault of the Proteus multiplayer template for Unreal, and the issue could be writing to a file or otherwise adding data to an array that must be processed at each frame. The issue can be fixed by starting the scene using "25 minutes play time" instead of 10 minutes.

Final System

Description

The purpose of the project is to develop a simulation environment for training nurses in participating in RAMIS. The simulation needs to allow trainees to practice different tasks and scenarios that might occur during real surgery or be part of physical training. The simulation should allow for three to four trainees and an instructor to be simultaneously in the same virtual operating room. In the room, trainees have access to all the tools and equipment that would be available to them in a physical training. At this point we are simulating only emergency undocking since it is one of the most important asks during procedure according to Jane Petersson. The simulation allows trainees to walk to move on short distance or teleport for long distance movement. Interactable objects in the simulation, such as tools and the robot, can be grabbed to carry and use. Tools are two types, hand tools and robot equipment. The hand tools are used mainly by the first assisting nurse. The robot equipment includes the camera and tools that can be attached to the arms. Trainees can interact with the robot by moving its arms to achieve optimal placement, which is required for proper functioning of the robot. Additionally, voice over IP (VOIP) service is implemented to support communication between the trainees.

Conclusion