TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 67, Issue Special II, April, 2024

DESIGN OF VIRTUAL HAND TO IMPROVE PROPRIOCEPTIVE FEEDBACK FOR UPPER-LIMB PROSTHETICS APPLICATIONS

Florin -Felix RĂDUICĂ, Ionel SIMION, Ioana –Cătălina ENACHE, Oana Roxana CHIVU

Abstract: Pattern recognition is used to control myoelectric prostheses. Although there is a significant amount of research in EMG, few studies are conducted about virtual training with prosthetics. Virtual testing may constitute a solution for further prosthesis development. Our aim was to develop a way of training patients. We modelled a human hand using Autodesk Maya. The model was then rigged and prepared for animation. The animated loops of main hand grasps were controlled with assigned keyboard shortcuts in the Unity environment. A virtual hand system was developed that can be controlled using the computer keyboard. We proposed future development with an open-source solution. Patients that need training with EMG may benefit by using a sensory bracelet with the proposed system.

Key words: p*rosthesis, virtual control, CAD modelling, animation, amputee training, virtual testing.*

1. INTRODUCTION

Prosthetics is a multidisciplinary field with applications in medicine, industrial engineering, robotics, automation, and many more. Usually, prosthetics are devices that aid in recovering some of the function lost through amputation. Although there are multiple ways of classifying them, they can be cosmetic, body-powered, or externally powered.

Cosmetic devices only solve psychological and social problems. The upper-limb cosmetic prosthetic is built to resemble the human hand in high fidelity, with no other functional considerations.

The body-powered devices also bring some functionality. An amputee can wear a special device to work and at home can change it with a device for activities of daily living specifically.

The externally powered devices are the most dexterous and where most of the current research literature gravitates.

A commercial prosthetic can offer some or all the functions back to the amputee in various degrees. Consequently, with dexterity comes an increase in price. Companies that sell prosthetic devices include Ottobock (Ottobock, Duderstadt, Germany) and Open Bionics (Open Bionics, Bristol, UK).

Another kind of prosthetics is the 3D printed open-source projects. These allow amputees and their friends to manufacture their own devices at a low cost. The constraints are mechanical reliability, functional control and fit. Although the maker must be proficient in CAD, the result is a custom prosthetic device. Due to their outlined problems, they can only be considered for transitional purposes only. A community for open-source projects like this is e-NABLE (3DUniverse LLC, Algonquin, USA).

Pattern recognition is used with externally powered prosthetics that have EMG sensors. The sensors can detect nerve activity and trigger a control loop. In the literature we can find experiments that have been conducted to learn the behaviour of a healthy hand. Then, with the gathered data, control systems have been trained. Amputees can benefit from these pattern recognition-based systems because they enable them to control prosthetics. In the present work we discuss how a system for gathering patter recognition data might be used to improve proprioceptive feedback of patients that use pattern recognition-based prosthetic devices.

This can constitute an opportunity to contribute to the development of low-cost learning systems for EMG-based 3D printed prosthetic devices.

1.1 Literature review

Development of prosthetics has gained an advantage. Most research has started to concentrate on 3D printed devices due to technology accessibility. Although the nature of 3D printing appeared to be disruptive for the prosthetic device sector, Savage et al 2019 [1] suggest that a positive outcome of this technology is the increase interest in prosthetic devices. Innovation in the field of 3D prosthetic devices can also benefit commercial non 3D printed devices.

Patients adapting to a prosthetic device have trouble with hand coordination due to proprioceptive feedback. In Bensmaia et al 2020 [2] the strategic development of Proprioceptive feedback to improve posture and movement of the limb is discussed. Non-invasive electrical feedback using EMG sensors to support electro tactile feedback to improve control of devices. Electrically generated artificial patterns evoke similar natural feedback to control dexterous prosthetics. The training of these sensory systems involves experimental trials with healthy individuals. The information can then be transferred to prosthetics. The work of Wali et al 2023 [3] focuses on training of retention of proprioceptive recalibration. They used a virtual reality experimental setup and although the test subjects were all healthy, the experiment did not permit a simulation of an amputee performance scenario to see how the participants performed.

Their findings suggest that retention of proprioceptive recalibration may last several days, degrading as time passes. However, the study presents the possibility of patients adapting to their prosthetic if the considered prosthetic is designed in a manner that enhances proprioceptive and visual feedback adaptability. In an earlier study of Pistohl et al 2015 [5] proprioceptive feedback trials with healthy subjects were done to train a computer system to perform myoelectric control.

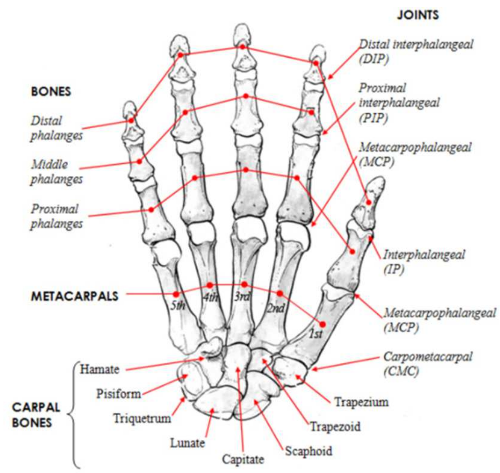


Fig.1. Reference image joint structure [4]

Artificial proprioceptive feedback in myoelectric control improves command of prosthetic devices.

Although the experiments were meant for hand amputation patients, the results may be useful for partial prosthetic device control as well. In the context of teleoperations for soft haptics used in human control interfaces. Mutlu et al 2023 [6] made a haptic device printed with fused deposition modelling (FDM) using Thermoplastic polyurethane (TPU).

Even though they didn't mention partial hand prosthetic application specifically, the works findings are important in bio applications to substitute proprioception. Furthermore, Boivin et al 2023 [7] use kinaesthetic feedback control to enable touch detection of a robot finger.

Consequently, the possibility of attaching such a sensor to a prosthetic device may be probable. Yao et al 2021 [8] describes a method for upper limb disfunction rehabilitation of stroke patients. They use a brain computer interface (BCI) and an augmented reality system (AR) to complete rehabilitation training. In this scenario the model hands are used in conjunction with the BCI AR technology for rehabilitation, but this can also be considered a starting point for proprioceptive feedback training as well.

Although learning human anatomy can be supported by virtual 3D models, having a complex model for simulation can be at a high computational cost. Zilverschoon et al 2017 [9] conclude that virtual 3D models are powerful educational tools. They used Autodesk Mudbox to model the hand and Unity to create the interface. In the end they built an educational and virtual dissection ready advanced anatomical hand model. In a previous study Ravichandiran et al 2012 [10] describes using 3D surface modelling of nerves to enable study of distribution of nerve branches. They digitized the radial nerve of several cadavers. The data could be used for modelling using curves. This allowed intermuscular innervation identification and documentation. A rendition of 3D members can prove to be more relevant than a 2D study as seen in the cited work. Furthermore, Husseini et al 2011 [11] discuss the exploration of online human server for orthopaedic anatomical study.

The virtual model was generated for anatomy studies from 2 scanned human cadavers. The user can slice the model and extract the result to be studied. Such a model can be used as a reference for modelling and anatomy study.

In the next sections, we present the steps taken to build a virtual 3D model of a human hand and the procedure to link it to a computer interface. This will enable the control of the model and aids in developing new ways of gathering information for future research.

1.2 Human hand modelling

Rapid growth of virtual reality technology has improved graphics research. In recent years, digital human modelling and animation simulation has emerged as one of the top research areas in computer graphics.

Consequently, light weighting, mesh optimization can be used relatively successfully in the medical area or in other fields. Furthermore, in industrial engineering, the shape optimization process is frequently used to create lightweight and efficient components. Shape optimization can be utilized to make a replacement bone, group of bones, or even a cast as lightweight and comfortable as possible for the amputee. Numerous smoothing techniques have been proposed in the literature, however those that modify vertex position suffer from excessive mesh shrinkage and the loss of crucial geometry features like holes and surface planarity [12]. Furthermore, digital human modelling technology is generally separated in (i) using anatomy-based digital human body modelling, (ii) using data from 3D scans, (iii) simulate the human body digitally, (iv) using image sequences as the basis for digital human body modelling, (v) human modelling in 3D software (such as 3Dmax, Maya, Blender) and (vi) parametric digital human body modelling technology are used [13].

Triangle meshes are now the most used way to represent 3D models in computer graphics. A 3D object is represented as a triangle mesh with the equations $M = (V, F)$ or $M = (V, E)$. Where M is a grouping of vertices (V), edges (E), and faces (F), each of which has three coordinates. The set of edges $E = e_{ij}$ connects two different vertices (v_i, v_j), and the set of faces $F = f_1 \dots f_m$ are defined by the number of edges. The control volumes are linked to the unknowns in cell-cantered approaches. In fact, any control volume correlates to a function value at some interior point (Centre of the polygonal surface). The unknowns in the vertex-centred methods are situated at the vertices of the control volumes, which are made up of polygonal cells [14].

If the meshes' local connectivity is insufficient for the given geometry, one or more sets of edges can be switched. If the mesh weave is too fine or too coarse in relation to the geometric complexity, then we must transfer vertices from one area to another via teleportation. Mesh enhancement requires two complementary operations, one for vertex removal and one for adding a vertex to the respective mesh [15].

To keep the algorithm simple, we focused on beginning from a good initial model with a suitable topology seen in figure 2, but which could be optimized as seen in figure 3.

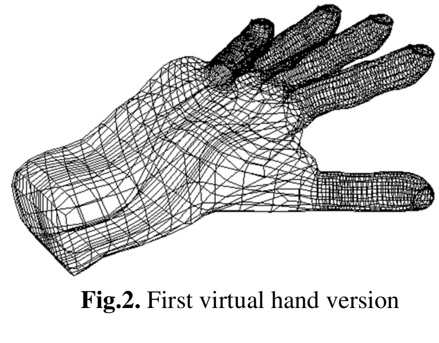


Fig.2. First virtual hand version

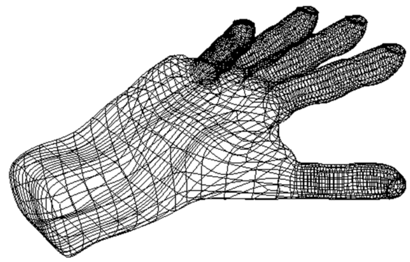


Fig.3. Model after topology optimization with hole removal and triads/quads removal

As a working methodology it is necessary to identify which parts of the mesh need to be optimized and which operations to use for local optimization of mesh geometry and connectivity.

1.3 Level of surface detail

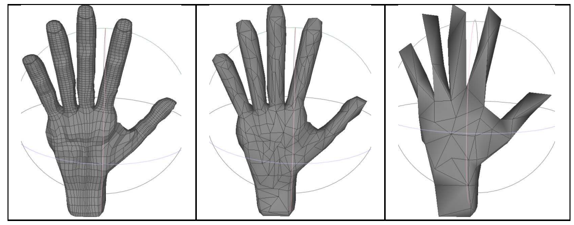
Many computer graphics applications necessitate elaborate, extremely detailed models, but in some cases the level of detail required may vary significantly. To reduce processing time, it is frequently preferable to employ approximations rather than overly detailed models. We can use MeshLab (visual computer Lab Istituto Di Scienza e Tecnologie dell'Informazione, Pisa, Italy) open-source software for a surface simplification approach that can quickly generate high-quality polygonal model approximations.

The approach simplifies models through iterative contractions of vertex pairs and preserves surface error approximations with quadric matrices. Algorithms can be used to generate simpler versions of polygonal models. Simplifying using Quadratic Edge Collapse Decimation is based on iterative vertex pair contraction (a generalization of edge contraction). The approach maintains a geometric error approximation at each vertex of the current model as it progresses. The initial model is made up of 10.124 faces generated from 5.064 vertices.

Table 1

Surface simplification.

FACES 10.124	FACES 1.000	FACES 150
VERTEX 5.064	VERTEX 502	VERTEX 77



In Table 1 we show that the 3D model from which we started was reduced to 150 faces (77 vertices) by repeated iterations. We stopped at this number in our situation because the model can be approximated with a hand but does not correspond to a genuine anatomy. We can restrict the size of the suggested model to 1000 faces for a more accurate approximation with a minimum number of faces/vertices.

The model we've provided will be utilized to perform specific movements, therefore we'll need enough vertices to accomplish this.

Using Uniform Mesh Resampling we create a new mesh based on the imported model's resampled version. Resampling is accomplished by creating a uniform volumetric representation in which each voxel carries the signed distance from the original surface. This approach can estimate the number of faces/vertices that can be used to reduce the area. In the case of the imported model, the area between two fingers has been combined, necessitating additional model revision. Using 3.872 faces, this approach yields 1.936 vertices. The number of faces/ vertices can be reduced after using Surface Simplification Using Quadric Error Metrics.

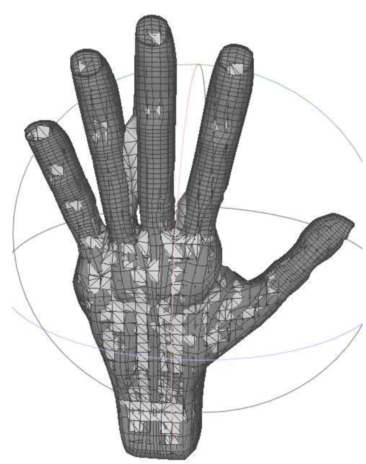


Fig.4. Uniform volumetric representation for the 3D model

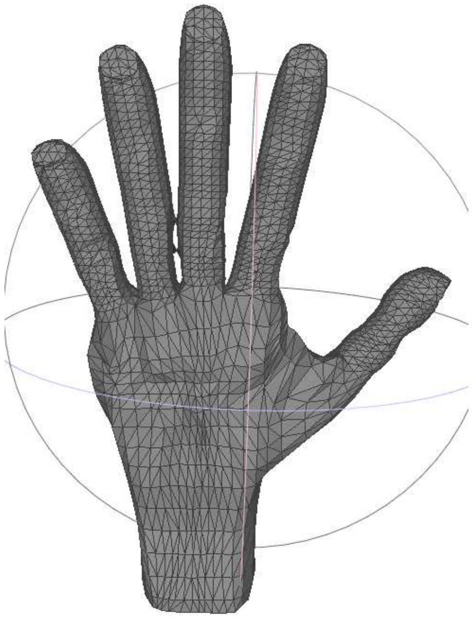


Fig.5. The result after using Clustering Decimation approach

Another alternative is to apply the Simplification: Clustering Decimation approach, which decreases the number of faces and vertices to 6.132 and 3.062, respectively. We can see that the fingers are no longer connected in this case.

Exaggerated surface detailing is essential in some circumstances. From oriented point sets, Poisson surface reconstruction generates watertight surfaces and is a well-known approach for generating watertight surfaces from oriented point samples obtained by 3D range scanners. The method can withstand noisy data and misregistration errors. However, as various academics have pointed out, it has a propensity to over-smooth the data. Our proposed surface is reconstructed to 12.852 vertices and 25.704 faces using this method. The number of faces/ vertices was reduced after using Surface Simplification Using Quadric Error Metrics.

In our suggested research, we will use the original model, and in future research, we will observe how the model acts when the number of vertices is lowered or raised.

2. MATERIALS AND METHODS

We modelled the virtual hand using Autodesk Maya 3D animation and visual effects software (Autodesk, San Francisco, CA, USA). The model was imported for control implementation into Unity Real-Time Development Platform (Unity Technologies, San Francisco, CA, USA). The software ran on a custom computer with a 2,4 GHz octa-core Ryzen 5 processor (Advanced Micro Devices, Santa Clara, CA, USA), a GeForce GTX 1660 dedicated graphics card with 6GB of video memory (NVIDIA, Santa Clara, CA, USA), 16GB DDR4 RAM system memory (Corsair, Milpitas, CA, USA) and Windows 11 Operating System (Microsoft, Redmond, WA, USA).

The initial picture of a human hand was imported as a reference image. This was placed on the Top plane and fixed for referencing purposes only. Other images were referenced from human anatomy atlas [16] and online image databases.

The reference skeletal structure described in the outline in figure 1 was used as reference for the placement of the joints in the rigging step of the process.

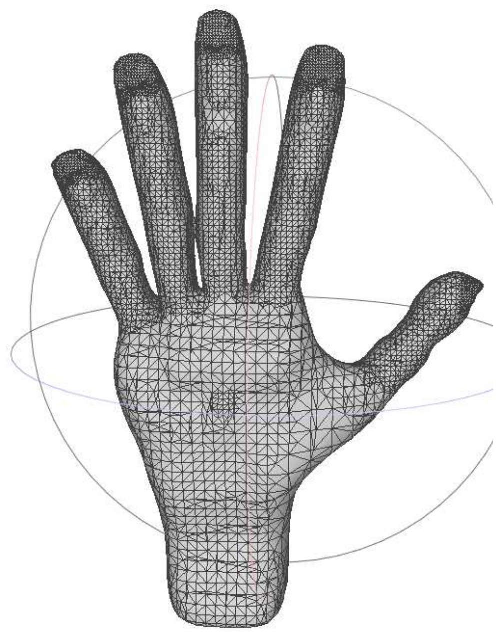


Fig.6. Smoothed surface reconstruction

In figure 2 the initial version of the virtual hand was modelled in Autodesk Maya. The initial vert count is low, and the resolution will be increased in later versions. Although the model complies with basic anatomic structure, there are topological improvements that can be made. For example, an increase in vert count, to improve the smoothness of the hand or a thorough analysis and removal of triangular faces for a better shape flow.

Initial modelling techniques involved reference images. Several reference images were considered and own hand for reference.

After the initial stage the model had anatomy fidelity but lacked flow of verts. Furthermore, due to the overlapping of verts some holes in the volume started to appear. Consequently, some mesh repairs have been done. In the case of the holes that appeared, this was since the fingers and palm were modelled separately and towards the end were brought together forming the holes in the model. In figure 3 the model has no holes, and some smoothness has been added to the mesh. This was done to further improve the model's quality and appearance. Moreover, this can aid in a better perception of the model when it is projected on a screen or a display device. Few steps need to be considered when adapting to different display technologies due to the model versatility.

For animation, joints have been added. In the Maya software each moving joint in the scenarios that will be described, had to be added to the geometry. This enabled the movement of the geometry in respect to their original state. The rigged model presented in figure 7 displays the degree of freedom around the model that can be moved to animate the virtual hand.

For the static hand position, two more movements are performed: one with the hand in the flex position (Figure 8) and one with the hand in the pinch position (Figure 9).

Every joint movement in Maya generates a curve that may be modified in the Graph Editor. These curves have been improved to obtain a more anatomical movement (Figure 10).

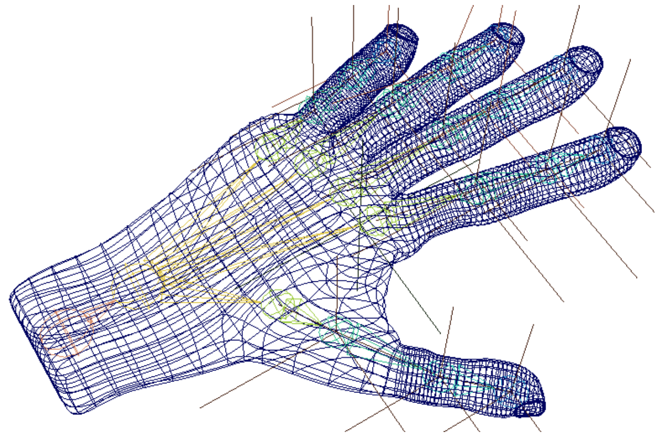


Fig.7. Rigged virtual hand version with joints

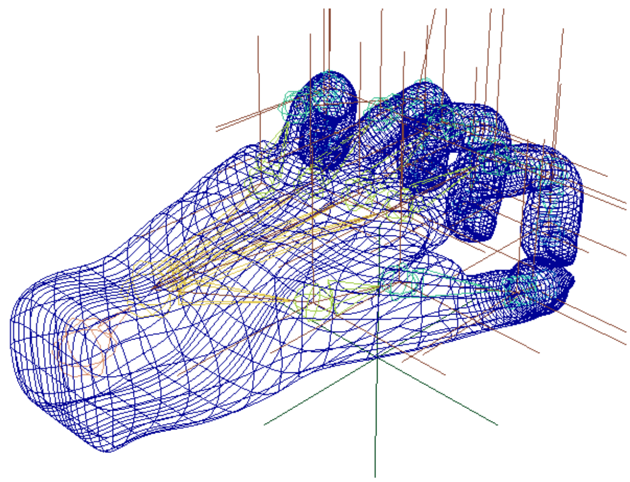


Fig.8. Model hand in flex position

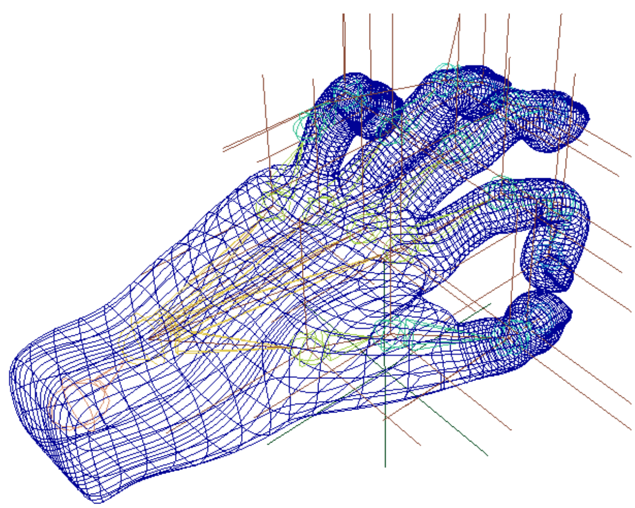


Fig.9. Virtual model in pinch position

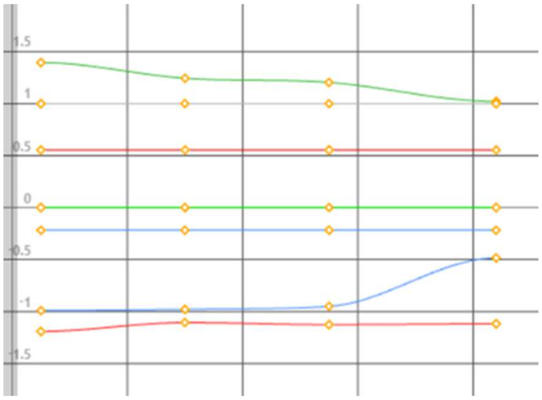


Fig.10. Graph Editor flex position animation

The generated model was exported to FBX file format several times. First, we exported the model in a static state. Then we exported the model with the flex animation attached. Finally, we exported the model with the pinch animation.

All 3 FBX files were imported into Unity. The interface project had a control script which is described with the help of the diagram in figure 14.

2.1 EMG sensors for virtual hand control

Sensing of muscular activity is done through electromyography. The sensors are placed on the surface of the skin to monitor the electrical current activity.

Firstly, the data is sent to the Unity platform and the development of the application can include steps as seen in figure 11.

Second, the algorithm checks the value gathered from the EMG. If the data extracted is saved in a variable, the application can compare against a set of configured values. If the variable is low, then the static virtual model is displayed. If the value is between low and moderate, then a pinch animation is displayed. If the value is bigger than the moderate set value, the animation of the flex hand is displayed. This restrictive movement is applied due to initial setup configuration; however, a more advanced experimental setup may offer the possibility of incorporating a wide range of movement.

Thirdly, the real-time data is not stored but rather the system reacts as it gets sent value to compare and send instructions to the display.

Finally, an improved all-around system with open-source hardware and software is considered moving forward with further research. Although the proposed schematic is not as robust as the Myo Gesture Control Armband (Thalmic Labs Kitchener, Ontario, USA), the proof of concept focuses on developing the methodology of improving proprioceptive feedback.

The human machine interface HMI presented in figure 12 is required to operate the virtual hand via body movement. The schematic was done using Fritzing electronic diagram drafting software (Fritzing, Berlin, Germany). The tabs of the myoelectric sensor (Sparkfun, Boulder, Colorado, USA) (red) are placed on a human hand to gather information. The data is sent to a microcontroller (Arduino, Somerville,

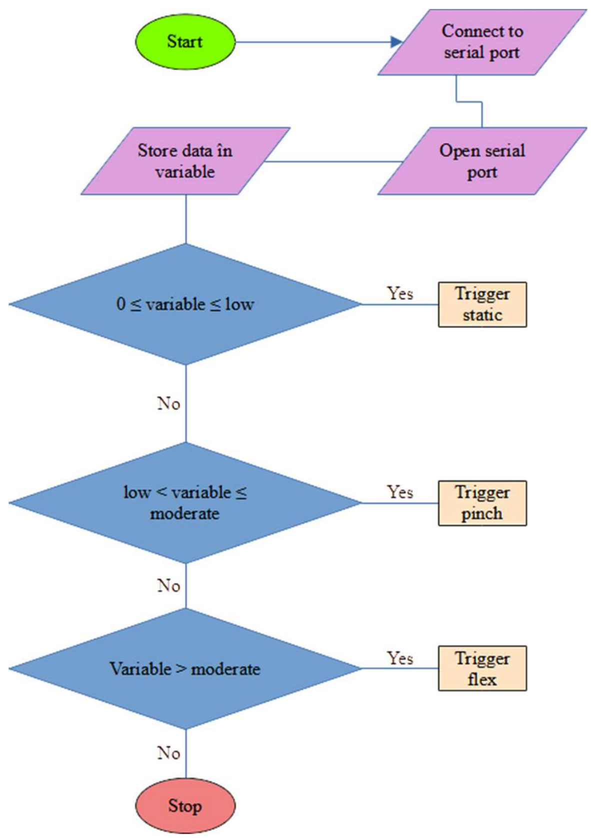


Fig.11. Block diagram of Unity to EMG connection

Massachusetts, USA) (blue) which communicates with a computer running the development platform described in earlier sections of the work. As seen in the figure, all equipment is battery powered (black/orange) to limit cables hanging from the user's arm and to prevent any damage that may occur.

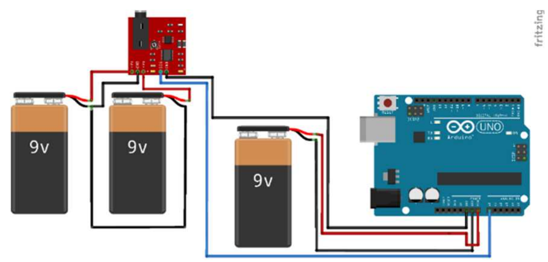


Fig.12. Electronic diagram of human computer interface

3. RESULTS

The cases for the model were as follows: (1) the initial model with minimal attention to flow and concentration on anatomy, (2) the version with more smoothness and some hole removal done because of initial modelling techniques, and (3) is the final version which underwent an analysis and removal of triangular surfaces.

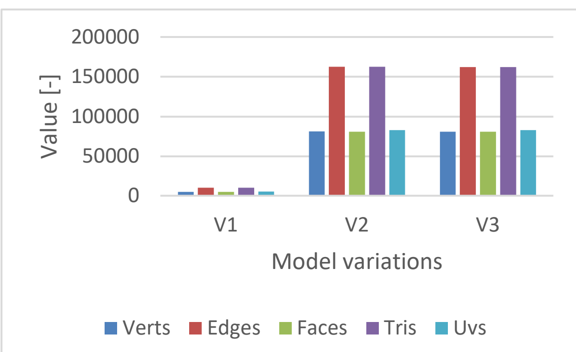


Fig.13. Comparison between number of verts, edges, faces, tris, and UVs for the 3 cases

As seen in figure 13 the number of verts, edges, faces, tries and UVs has grown substantially from the first model to the second model for reasons explained previously. The difference between the second and final model isn't significant because the model only had some minor improvements done to it.

The Unity algorithm described in figure 14 is implemented in a C# script that controls the triggering of animations.

From the start time of the script the application waits for user input. If a certain key, corresponding to animation trigger, is pressed then the algorithm will travel along the block diagram or else it will remain static and display a sitting hand. If the user presses the first assigned key, then the application will play the animation which it corresponds to. Or else, if the user presses the second key it will trigger the second animation assigned to it. In this case the first animation is the pinch and the second is the flex movement of the virtual hand. If another key is pressed the application will do nothing and will remain on the neutral position.

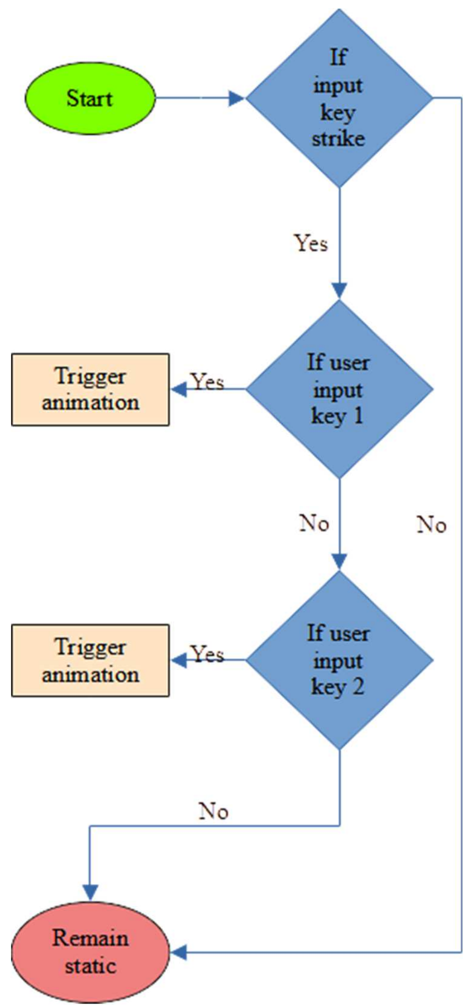


Fig.14. Unity algorithm block diagram

At this point, the application is setup to use a keyboard input to control the virtual hand in the Unity platform. Although there are only 2 animations and 3 states in total, this can be extrapolated in future research to more hand movement positions as described by the GRASP taxonomy [17]. Moreover, this can be further enhanced to take advantage of Unity's collision system which allows collider addition and interaction between objects included in the current scene. Consequently, this can allow further development of the proposed work for improving proprioceptive feedback and allowing for human – machine interaction through auxiliary equipment.

4. DISCUSSION AND CONCLUSIONS

In comparison with [3] our study considers the equipment necessary to conduct experiments using 3D systems rather than 2D systems presented in the cited work. As for the work of Mutlu et al [5] the experiments included 2 people sensing the actions of one as feedback to the other person. In the case of the present work, the system conveys the feedback on screen to a virtual hand model. Like [9] we modelled a virtual hand to aid in the research of proprioceptive feedback improvement for prosthetics users. Although the described model here is not as detailed as the one of [8] and [10] the resulting application is suitable for proprioceptive hand training.

Usually, we find research on topological optimization either when it comes to finite element analysis [18] or in the case of design preparation for additive manufacturing [19]. However, in our case we used it to develop a virtual model and enhance proprioceptive feedback while reducing the uncanny valley effect [20]. Thus, the presented model benefited from topological optimization adapted from other fields.

In the sections presented virtual experimentation has been done to strike a balance between high fidelity and topological optimization for a virtual human hand model. We described first steps towards a proprioceptive feedback system used for training of patients and for pattern recognition studies. Although quite a lot of work has been presented in this paper, more work must be done to perfect the systems. Limitations include no practical experiment work. However, this constitutes a path for future research.

5. REFERENCES

[1]"The Case For Broad-Range Outcome Assessment Across Upper Limb Device Classes | Canadian Prosthetics & Orthotics Journal," Oct. 2019.

[2]Bensmaia, S.J., Tyler, D.J., Micera, S. "Restoration of sensory information via bionic hands," *Nat. Biomed. Eng.*, vol. 7, no. 4, Art. no. 4, 2020, doi: 10.1038/s41551-020-00630-8.

[3]Wali, M., Lee-Miller, T., Babu, R., Block, H.J. "Retention of visuo-proprioceptive recalibration in estimating hand position," *Sci. Rep.*, vol. 13, no. 1, Art. no. 1, Apr. 2023, doi: 10.1038/s41598-023-33290-0.

[4]Nanayakkara, V.K., Cotugno, G., Vitzilaios, N., Venetsanos, D., Nanayakkara, T., Sahinkaya, M. N. "The Role of Morphology of the Thumb in Anthropomorphic Grasping: A Review," *Front. Mech. Eng.*, vol. 3, 2017.

[5]Pistohl, T., Joshi, D., Ganesh, G., Jackson, A., Nazarpour, K. "Artificial Proprioceptive Feedback for Myoelectric Control," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 23, no. 3, pp. 498–507, May 2015, doi: 10.1109/TNSRE.2014.2355856.

[6]Mutlu, R., Singh, D., Tawk, C., Sariyildiz, E. "A 3D-Printed Soft Haptic Device with Built-in Force Sensing Delivering Bio-Mimicked Feedback," *Biomimetics*, vol. 8, no. 1, Art. no. 1, Mar. 2023, doi: 10.3390/biomimetics8010127.

[7]Boivin, M., Lin, K.-Y., Wehner, M., Milutinović, D. "Proprioceptive Touch of a Soft Actuator Containing an Embedded Intrinsically Soft Sensor using Kinesthetic Feedback," *J. Intell. Robot. Syst.*, vol. 107, no. 2, pp. 1–18, Feb. 2023, doi: 10.1007/s10846-023-01815-4.

[8]Yao, Y., Yang, B., Xia, X., Peng, Z., Gao, S., Meng, X. "Design of Upper Limb Rehabilitation Training System Combining BCI and AR Technology," in *2021 40th Chinese Control Conference (CCC)*, Jul. 2021, pp. 7131–7134. doi: 10.23919/CCC52363.2021.9550315.

[9]Zilverschoon, M., Vincken, K.L., Bleys, R.L.A.W., "The virtual dissecting room: Creating highly detailed anatomy models for

educational purposes," *J. Biomed. Inform.*, vol. 65, pp. 58–75, Jan. 2017, doi: 10.1016/j.jbi.2016.11.005.

[10] Ravichandiran, M. *et al.*, "Neuromuscular partitioning in the extensor carpi radialis longus and brevis based on intramuscular nerve distribution patterns: A three-dimensional modeling study," *Clin. Anat.*, vol. 25, no. 3, pp. 366–372, Apr. 2012, doi: 10.1002/ca.21246.

[11] Husseini, T.F.E., Mahran, M.A. "Online orthopaedic surgical anatomical study using the visible human server," *Eur. J. Orthop. Surg. Traumatol.*, vol. 21, no. 4, pp. 225–230, May 2011, doi: 10.1007/s00590-010-0695-4.

[12] Bacciaglia, A., Ceruti, A., Liverani, A. "Surface smoothing for topological optimized 3D models," *Struct. Multidiscip. Optim.*, vol. 64, no. 6, pp. 3453–3472, Dec. 2021, doi: 10.1007/s00158-021-03027-6.

[13] Su, G., Hu, X., Li, J., Yin, W., Chen, S. "Mesh smoothing of human body model based on Sqrt3 subdivision algorithm," in *2017 IEEE International Conference on Circuits and Systems (ICCS)*, Dec. 2017, pp. 124–128. doi: 10.1109/ICCS1.2017.8325976.

[14] Sidaoui, S., Kacem, A., Asmi, S.E. "A Finite Volume Variational Approach for 3D Mesh Smoothing," in *2018 Seventh International Conference on Communications and Networking (ComNet)*, Nov. 2018, pp. 1–5. doi: 10.1109/COMNET.2018.8622295.

[15] Lindstrom, P., Turk, G. "Image-Driven Mesh Optimization".

[16] Netter, F. *Netter Atlas of Human Anatomy: A Systems Approach*. in Elsevier Health. Elsevier, 2022.

[17] Feix, T., Romero, J. H.-B. Schmiedmayer, A. M. Dollar, and D. Kragic, "The GRASP Taxonomy of Human Grasp Types," *IEEE Trans. Hum.-Mach. Syst.*, vol. 46, no. 1, pp. 66–77, Feb. 2016, doi: 10.1109/THMS.2015.2470657.

[18] Nayak, C., Singh, A., Chaudhary, H. "Topology optimisation of transtibial prosthesis socket using finite element analysis," *Int. J. Biomed. Eng. Technol.*, Jul. 2017.

[19] Hällgren, S., Pejryd, L., Ekengren, J. "(Re)Design for Additive Manufacturing," in *Procedia CIRP*, in 26th CIRP Design Conference, vol. 50. Jan. 2016, pp. 246–251. doi: 10.1016/j.procir.2016.04.150.

[20] "The Aesthetic Appeal of Prosthetic Limbs and the Uncanny Valley: The Role of Personal Characteristics in Attraction," *Int. J. Dsign*.

Proiectarea virtuală a membrului superior uman pentru a îmbunătăți propriocepția cu aplicații în protezare

Detectarea șabloanelor este folosită pentru a controla protezele mioelectrice. Deși există un număr însemnat de lucrări de cercetare în domeniul electromiografiei, puține tratează problema antrenării virtuale pentru folosirea protezelor. Obiectivul acestei lucrări a fost descrierea unei căi pentru instruirea pacienților. În cadrul lucrării am modelat un membru superior uman folosind Autodesk Maya. Am articulat modelul și l-am pregătit pentru a fi animat. Buclelor animate li s-a adăugat câte o combinație de taste pentru a simula poziții tipice ale mâinii folosind Unity. În această lucrare a fost creat un sistem virtual care poate fi controlat de la tastatură. Am propus cercetări viitoare bazate pe sisteme alternative Open-source, Pacienții ce necesită instruire pentru folosirea unei proteze cu EMG pot folosi sistemul propus.

Florin – Felix RĂDUICĂ, PhD Candidate, Assistant Professor, NUST POLITEHNICA of Bucharest, Splaiul Independenței 313 6th District, Bucharest, Romania, felix.raduica@upb.ro

Ionel SIMION, PhD Professor, NUST POLITEHNICA of Bucharest, Splaiul Independenței 313 6th District, Bucharest, Romania, ionel.simion@upb.ro

Ioana – Cătălina ENACHE, PhD Lecturer, NUST POLITEHNICA of Bucharest, Splaiul Independenței 313 6th District, Bucharest, Romania, catalina.enache@upb.ro

Oana Roxana CHIVU, PhD Professor, NUST POLITEHNICA of Bucharest, Splaiul Independenței 313 6th District, Bucharest, Romania, virlan_oana@yahoo.co.uk