Neutrosophic Sets and Systems, Vol. 82 2025
University of New Mexico

Neutrosophic CRITIC MCDM for Prosthesis Rehabilitation, its Applications and Technologies

Huda E. Khalid[1*], Ibrahim Bahjat Ibrahim[2], A. A. Salama[3], Ahmed K. Essa[4], Maher Noorlden Saaed[5], Muhammad Mustaffa Hussein[6]

[1,4] University of Telafer, The Administration Assistant for the President of the Telafer University, Telafer, Iraq; https://orcid.org/0000-0002-0968-5611 , dr.huda-ismael@uotelafer.edu.iq, ahmed.k.essa@uotelafer.edu.iq

[2]Quality Assurance and University Performance Department Telafer University, Telafer, Iraq.

[3]Department of Mathematics and Computer Science, Faculty of Science, Port Said University, Port Said, Egypt.

ahmad.elsherif@sci.psu.edu.eg, drsalama44@gmail.com, ahmed_salama_2000@sci.psu.edu.eg

[5,6] Department of Management Information Systems, University of Mosul, Iraq.

*Correspondence: dr.huda-ismael@uotelafer.edu.iq

Abstract: Prosthesis rehabilitation plays a crucial role in supporting amputees to return to their normal life through increasing mobility, utility, and comfort. Prostheses design during production in VR- Metaverse depends on clients' requirements and many other factors, such as comfort, use, and operation. There are also sub-factors within these factors as illustrated in Figure (1). Several overlapping criteria must be considered when making decisions in this field. Thus, an efficient multi-criteria decision-making (MCDM) technique needs to be employed. One promising technique is the Neutrosophic CRITIC (Criteria Importance Through Intercriteria Correlation) MCDM. In this paper, the fundamentals of the Neutrosophic CRITIC MCDM are discussed, focusing on its applications in prosthesis rehabilitation and the associated technologies that enhance the decision-making process.

Keywords: CRITIC, MCDM, Prosthesis Rehabilitation, Uncertain Data.

1. Introduction

Prosthetic rehabilitation manufacturing involves a complicated decision-making process due to the several factors affecting its work. This includes cost, durability, biomechanical efficiency, patient comfort, and material selection [1]. Unfortunately, due to the inherent uncertainty and subjectivity of these factors, traditional decision-making techniques are often incapable of dealing with these issues.

If neutrosophic logic is combined with the CRITIC method, a more effective solution can be harvested to model and process uncertainty, leading to more intelligent and adaptive rehabilitation strategies [2,3].

The motivation behind using neutrosophic logic for prosthetic systems is that such systems suffer from:

- Noisy sensor signals.
- Uncertainty of the interaction process between the amputees and the device.

These data uncertainties can be managed through the structured manner of neutrosophic theory tools, producing prosthetics with better flexibility and responsiveness.

Figure (1) presents the factors in the prosthetic production design.

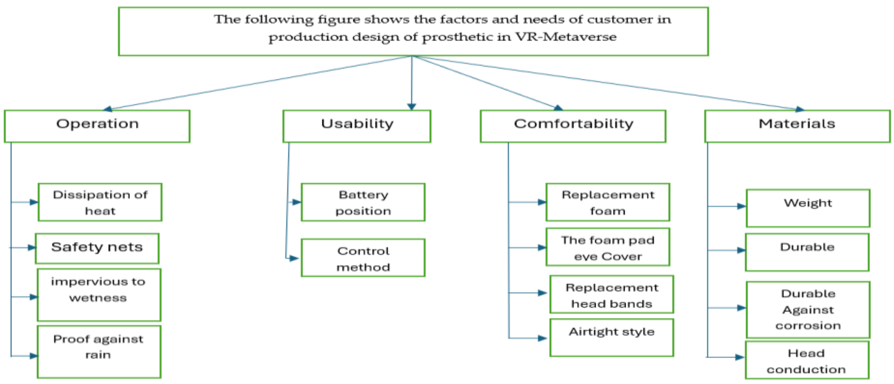

Figure (1): The factors in the prosthetic design

2. Prosthetic Design using Neutrosophic CRITIC MCDM

Adopting Neutrosophic CRITIC MCDM in prosthetic design can offer different merits which include:

1) Prosthetic devices can adapt to the changes in environmental conditions and user inputs by ranking and assessing control factors.

2) Neutrosophic theory can control uncertain inputs from sensors, thus the sensory feedback mechanisms can be improved, which in turn enhances the user's sense of control and natural movement.

3) Neutrosophic CRITIC MCDM can also offer another advantage by prioritizing many factors, such as heat dissipation, weight distribution, and control mechanisms, resulting in more user-centered prosthetic designs.

3. Case Studies

2.1. Case Study 1 [4]: Adaptive Bionic Limb with Neutrosophic-Based Control

A neutrosophic-based adaptive control system is installed on a prosthetic limb. Utilizing the CRITIC MCDM technique helps to prioritize control signals according to environmental factors, sensor data, and user feedback, allowing more accurate and timely adjustments.

2.2. Case Study 2 [5]: Supporting Myoelectric Devices with Sensory Feedback

Neutrosophic sensory feedback can be integrated with the myoelectric prosthetics to enhance user reaction as a result of improved handling of indeterminate signals. Patients reported that their prosthetic was easier to operate and it adapts better to incomplete and unclear muscle signals.

3. Key Findings [6]

3.1. Utilizing neutrosophic based control systems techniques in prosthetics leads to better user adaptability.

3.2. Adapting neutrosophic logic assists prosthetic systems to handle uncertain data more effectively.

3.3. By prioritizing design factors like weight, thermal management, and control mechanisms, the CRITIC MCDM technique can allow more comfortable and functional prosthetics.

4. The Challenges and Limitations [6,7]

- Often, the implementation of neutrosophic systems in control algorithms to serve prosthetics requires considerable computational capabilities.
- The calibration of the parameters for different prosthetics users can be complicated because of the variations in physical conditions and user preferences.

- There are some concerns about data privacy arising when collecting usage data from users.
- There is a requirement that the decision-making algorithms need to be objective and unbiased for equitable user experience.

5. Future Research Directions

5.1. There is a possibility of combining neutrosophic logic with AI technology to create hybrid models such as machine learning or neural networks that could lead to more accurate prosthetic systems with higher adaptivity.

5.2. Future research can focus on personalizing the usage of prosthetic devices through adopting user-specific neutrosophic models, thus enabling better adaptivity to individual preferences.

5.3. The optimization of neutrosophic CRITIC MCDM algorithms for real-time requirements could extend their use in daily prosthetic activities.

6. Conclusion

The Neutrosophic CRITIC MCDM methodology provides a promising possibility to develop prosthetic systems through dealing with uncertainty, indeterminacy, and contradicted information. By manipulating more responsive, adaptive and user-centered prosthetics, this method represents an important step forward in introducing sophisticated decision-making frameworks into medical utilities.

Acknowledgement

This research is supported by the Neutrosophic Science International Association (NSIA) in both of its headquarters at New Mexico University and its Iraqi branch at the University of Telafer. For more details about (NSIA) see the URL http://neutrosophicassociation.org/.

Conflicts of Interest: The authors declare no conflict of interest.

References:

1. Smarandache, F. (1999). A unifying field in Logics: Neutrosophic Logic. In Philosophy (pp. 1-141). American Research Press.
2. Smarandache, F. (2022). Operators on single-valued neutrosophic oversets, neutrosophic undersets, and neutrosophic offsets. Collected Papers, 9, 112.

3. Rathore, M. M., Shah, S. A., Shukla, D., Bentafat, E., & Bakiras, S. (2021). The role of ai, machine learning, and big data in digital twinning: A systematic literature review, challenges, and opportunities. IEEE Access, 9, 32030-32052.
4. Salama, A. A., Shams, M. Y., Elseuofi, S., & Khalid, H. E. (2024). Exploring Neutrosophic Numeral System Algorithms for Handling Uncertainty and Ambiguity in Numerical Data: An Overview and Future Directions. Neutrosophic Sets and Systems, 65, 253-295.
5. Ahmed Sleem, Nehal Mostafa, Ibrahim Elhenawy (2023). Neutrosophic CRITIC MCDM Methodology for Ranking Factors and Needs of customers in Product's Target Demographic in Virtual Reality Metaverse. Neutrosophic Systems with Applications, Vol.2.
6. Esra Aytac Adali, Tayfun Oztas, (2023). A New Multi-Criteria Decision-Making Method Under Neutrosophic Environment: ARAS Method with Single-Valued Neutrosophic Numbers. International Journal of Information Technology & Decision Making, Vol. 22, No. 1.
7. Vladimir Simic, Ilgin Gokasar, Muhammet Deveci, Ahmet Karakurt (2021). An integrated CRITIC and MABAC based type-2 neutrosophic model for public transportation pricing system selection. Socio-Economic Planning Sciences, 80, 2022, 101157.

Received: Oct. 9, 2024. Accepted: March 20, 2025