

# VIDYAPATI KUMAR

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 Google Scholar  LinkedIn  ResearchGate

## PROFILE

Ph.D. candidate in Mechanical Engineering at IIT Kharagpur, specializing in AI-driven biomechatronic systems, advanced manufacturing, and multi-objective optimization. My research integrates machine learning, sensor fusion, and embedded systems for intelligent prosthetics, wearable health technologies, and process optimization. I have published peer-reviewed journal articles, contributed to edited books, and hold a patent and software copyright. With interdisciplinary expertise spanning biomedical engineering, robotics, and smart manufacturing, I aim to contribute to cutting-edge research in AI-enabled systems and real-world healthcare innovations through a postdoctoral position.

## EDUCATION

Graduation Year	Degree	Institute	CGPA
2025 (Pursuing)	Ph.D. (Mechanical Engineering)	IIT Kharagpur, India	8.5 / 10
2018	M.E. (Production Engineering)	Jadavpur University, India	8.38 / 10
2016	B.Tech (Mechanical Engineering)	MAKAUT, India	9.19 / 10

## EXPERIENCE

<b>Senior Research Fellow – AI-Enhanced Powered Ankle-Foot Prosthetic System</b> <i>Indian Institute of Technology Kharagpur</i>	Jul. 2021 – Present <i>Kharagpur, India</i>
<ul style="list-style-type: none"><li><b>Embedded IoT Systems &amp; Sensor Fusion:</b> Designed a microcontroller-based sensor fusion platform using ESP32 and Raspberry Pi, enabling real-time terrain classification via LiDAR and IMU data streams. Integrated Novella Dot sensors for full-body motion capture and analyzed data in OpenSim to study musculoskeletal dynamics.</li><li><b>Prosthetic Gait Control &amp; Motor Actuation:</b> Developed a multimodal control strategy for powered ankle-foot prosthesis using 16-channel FSR insole sensors, IMUs, and Maxon motors to detect gait phases and drive adaptive actuation.</li><li><b>Machine Learning &amp; Explainability:</b> Built comprehensive Python-based pipelines using pandas, NumPy, and SciPy for data processing, model training, and evaluation. Employed SHAP values to interpret classification results, achieving over 90% accuracy in gait phase detection.</li><li><b>Computer Vision for Gait Analysis:</b> Implemented video-based kinematic analysis using Vision Transformers, YOLOv8, OpenPose, and custom background subtraction techniques. Generated Gait Energy Images (GEIs) and achieved classification accuracy above 96% for orthopedic pathologies. Used Grad-CAM and attention maps for model interpretability.</li><li><b>Material Optimization &amp; Structural Validation:</b> Performed multi-criteria material selection for cost-efficient prosthetic design. Validated stress and load distribution under varying conditions using finite element analysis (FEA) in COMSOL.</li><li><b>LLM-Driven Clinical Decision Support:</b> Developed <i>CDS ProsthicX</i>, an LLM-powered tool using LangChain and Streamlit for personalized, evidence-based prosthetic recommendations.</li><li><b>Experimental Validation:</b> Conducted extensive sensor-based trials across diverse terrains to assess system performance and control reliability under varying load and environmental conditions.</li></ul>	
<b>Project Mentor – TIH Foundation for IoT and IoE (IIT Bombay)</b> <i>IIT Bombay &amp; DST (Government of India)</i>	Feb. 2024 – Present <i>Kharagpur, India</i>
<ul style="list-style-type: none"><li><b>Chanakya Fellowship Project:</b> Mentoring a prestigious project funded by the DST, Government of India, under the Chanakya Fellowship Scheme (No. TIH-IoT/2024-02/HRD/CHANAKYA/SL/CFP/087, dated 19th Feb 2024), titled <i>“Development of Intelligent and User-Friendly Prosthetic for Real-World Applications”</i>. This initiative is supported by the TIH Foundation for IoT and IoE at IIT Bombay.</li><li>Leading the design and deployment of an end-to-end IoT-enabled prosthetic system involving embedded platforms, real-time data acquisition, and control integration.</li><li>Coordinating cross-functional teams across hardware, firmware, and cloud layers; guiding prototyping, testing, and version control; and mentoring Master’s and undergraduate students.</li></ul>	

- Engaging with DST program managers and industry collaborators to ensure milestone delivery, budget compliance, and translational impact in assistive technology.

### Teaching Assistant – NPTEL Courses

Jan. 2021 – Present

IIT Kharagpur

Kharagpur, India

- Assisted Prof. D.K. Pratihari in delivering NPTEL courses on Robotics, Fuzzy Logic, and Optimization Tools, including developing code examples in Python and MATLAB.

### Faculty – GATE (Mechanical)

Aug. 2020 – Dec. 2020

Unacademy (Online EdTech)

Remote

- Taught GATE aspirants subjects such as Manufacturing, Strength of Materials, Thermodynamics, and Engineering Mathematics, including problem-solving sessions and mock tests.

### Project Assistant – Design Guidelines for Underground Coal Extraction

Aug. 2018 – Mar. 2020

CSIR-Central Institute of Mining and Fuel Research

Dhanbad, India

- Developed CAD models and conducted numerical simulations to optimize extraction parameters for deep coal seams (300 m+ depth), and collected geo-mining data for MATLAB-based optimization algorithms to enhance mine safety guidelines.

### M.Tech Thesis: Development of an Intelligent Advisory System for NTM Processes

Aug. 2016 – Mar. 2018

Jadavpur University

Kolkata, India

- Designed a VBASIC-based expert system to recommend optimal parameters for Non-Traditional Machining (NTM) processes, based on material and geometric inputs.
- The system predicts process responses and suggests feasible settings to meet target outcomes—validated using multiple real-time case scenarios.

### B.Tech Thesis: Development of an Assistive System for Visually Impaired Persons

Aug. 2015 – Mar. 2016

Maulana Abul Kalam Azad University of Technology

Kolkata, India

- Built an Arduino-based navigation system using ultrasonic and PIR sensors, integrated into a wearable shoe, belt, and cap for obstacle detection.
- Designed user interface and control logic to manage sensor alerts, ensuring reliable guidance for visually impaired users.

## SELECTED PATENTS AND COPYRIGHTS

### 1. A Compact and Powered Ankle-Foot Prosthetic Device

2024

Indian Patent Application No. 202431037184 (Published & Under Examination)

Kharagpur, India

- Developed a prosthetic device addressing limitations of conventional systems through real-time foot height and ankle angle adjustments.
- Integrated a spring-loaded split forefoot to enhance shock absorption and push-off dynamics during gait.
- Engineered a hybrid actuation system (active + passive) to improve stability and mobility for transtibial amputees.

### 2. ProsthetiX-AI – Clinical Decision Support System for Ankle-Foot Prosthetic Recommendations

2025

Indian Copyright Application No. 9678/2025-CO/SW

Kharagpur, India

- Designed and implemented a copyright-registered clinical decision support tool for ankle-foot prosthetic prescriptions.
- Powered by LLMs, LangChain, and Streamlit; integrates explainable AI, K-level logic, and real-time academic citation justification for clinical use.

[Both Patent and Copyright Documents Available Here]

## SELECTED PUBLICATIONS

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1. **Kumar, V., Pratihari, D. K. (2025).** Wearable sensor-based intent recognition for adaptive control of intelligent ankle-foot prosthetics. *Measurement: Sensors*, 39, 101865. Elsevier. (Published)
  - Developed an intent recognition system using **wearable FSR and accelerometer data** to classify gait speed and terrain inclination.
  - Achieved **96.3% accuracy** using **SBLSTM**, outperforming CNN, KNN, and ANFIS in both accuracy and inference speed (25 ms).
2. **Kumar, V., Pratihari, D. K. (2025).** Biomechanical material selection for ankle-foot prosthetics: An ensemble MCDM-FEA framework. *International Journal on Interactive Design and Manufacturing (IJIDeM)*. (Published)
  - Developed a hybrid MCDM-FEA model to rank prosthetic materials based on mechanical strength, fatigue, and damping.
3. **Kumar, V., Pratihari, D.K. (2025).** ProsthetiX-AI: An LLM-based clinical decision support system for evidence-based prosthetic recommendations. *Health Information Science and Systems*. (Under Review)
  - Designed an LLM-integrated CDSS tailored for prosthetic prescriptions using structured medical inputs and evidence-based guidelines.
4. **Kumar, V., Hrishikesh, M.V., Shijas, M., Pratihari, D.K. (2024).** Mechatronic and AI-driven framework for non-invasive screening of knee abnormalities using multimodal sensors. *Computer Methods in Biomechanics and Biomedical Engineering*. (Accepted)
  - Combined **sEMG** and goniometer data for early knee abnormality detection.
  - Achieved **92.3% cross-validated accuracy** with **Extra Trees classifier**; used **SHAP analysis** for interpretability.
5. **Kumar, V., Pratihari, D.K. (2024).** Multimodal sensor fusion for early knee disorder detection and injury prevention using prosthetic gait control. *International Journal of Injury Control and Safety Promotion*. (Under Review)
  - Integrated **EMG-goniometry** signals with **Extra Trees classifier (92.19% test accuracy)**.
  - Designed **prosthetic gait control system** using **XGBoost (0.992 accuracy)**; identified **Willison Amplitude** as the key feature.
6. **Kumar, V., Prakash, R. R., Pratihari, D.K. (2024).** Automated detection of gait disorders in orthopedic pathologies using an interpretable vision transformer framework. *Health Information Science and Systems*. (Under Review)
  - Proposed **ViTGA** framework using Vision Transformer and Gait Energy Images for diagnosis of knee osteoarthritis and Parkinson's disease.
  - Achieved **98% validation accuracy** in 10 epochs; added **saliency maps** and **Grad-CAM** for interpretability.
7. **Kumar, V., Pratihari, D. K. (2024).** Vision Transformer-based pose estimation for automated gait analysis in ankle-foot prosthetic design. In *2024 2nd Int'l Conf. on Advancement in Computation & Computer Technologies (InCACCT)* (pp. 641–645). IEEE. (Presented)
  - Benchmarked **YOLOv8**, **DeepPose**, and **RTM Pose** models for automated gait analysis.
  - Achieved **MAE = 19.75**, **R<sup>2</sup> = 99.5%**, and **107.7 ms inference time** using RTM Pose.
8. **Kumar, V., Hrishikesh, M. V., Shijas, M., Pratihari, D. K. (2024).** Terrain recognition for intelligent powered ankle-foot prosthetics using sEMG and ensemble learning models. In *2024 IEEE 21st India Council Int'l Conference (INDICON)* (pp. 1–6). IEEE. (Presented)
  - Developed terrain classification framework using **sEMG signals** from 9 lower-limb muscles.
  - Optimized **Extra Trees classifier** achieving **87% accuracy** and **0.88 F1 score**.

9. Gupta, P., Nahak, P., **Kumar, V.**, Pratihari, D. K., Deb, K. (2025). Comparative evaluation of deep learning techniques for multistage Alzheimer's prediction from magnetic resonance images. In *Biomedical Robots and Devices in Healthcare* (pp. 135–151). Elsevier. (Published)
  - Trained **VGG-16** on 12,800 augmented MRI images for multiclass AD staging.
  - Achieved **89.92% test accuracy** with superior performance in mild dementia detection.
10. **Kumar, V.**, Gupta, P., Pratihari, D. K. (2025). Advancing ankle-foot orthosis design through biomechanics, robotics, and additive manufacturing: A review. In *Biomedical Robots and Devices in Healthcare* (pp. 65–84). Elsevier. (Published)
  - Provided a comprehensive review integrating **biomechanics, additive manufacturing, and control strategies** for AFO design.
  - Proposed future directions incorporating **AI-driven adaptation** and **soft robotics**.
11. **Kumar, V.**, Gupta, P., Pratihari, D. K. (2024). A research perspective on ankle-foot prosthetics designs for transtibial amputees. In *Mechanical Engineering in Biomedical Applications: Bio-3D Printing, Biofluid Mechanics, Implant Design, Biomaterials, Computational Biomechanics, Tissue Mechanics* (pp. 397–412). Wiley. (Published)
  - Reviewed current transtibial prosthetic designs, materials, and biomechanics.
  - Emphasized challenges and scope for improvement in **user-adaptable** and **energy-efficient** designs.
12. **Kumar, V.**, Prakash, R. R., Pratihari, D. K. (2025). Intelligent ankle-foot prosthetics: From engineering fundamentals to integrated artificial intelligence systems. In *Advancing Healthcare Through Decision Intelligence* (pp. 127–147). Elsevier. (Published)
  - Presented an end-to-end overview of intelligent AFO design integrating **mechatronics, AI, and sensor fusion**.
  - Proposed a modular framework for intent-adaptive prosthetic control systems.

#### ADDITIONAL JOURNAL PUBLICATIONS

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1. **Kumar, V.**, Mistri, A. (2025). Fuzzy logic-based synchronization of trajectory planning and obstacle avoidance for RRP SCARA robot. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 1–14.
2. **Kumar, V.**, Kalita, K., Chatterjee, P., Zavadskas, E. K., & Chakraborty, S. (2022). A SWARA-CoCoSo-based approach for spray painting robot selection. *Informatica*, 33(1), 35–54.
3. **Kumar, V.**, Diyale, S., & Chakraborty, S. (2020). Teaching-learning-based parametric optimization of an electrical discharge machining process. *Facta Universitatis, Series: Mechanical Engineering*, 18(2), 281–300.
4. **Kumar, V.**, Das, P. P., & Chakraborty, S. (2020). Grey-fuzzy method-based parametric analysis of abrasive water jet machining on GFRP composites. *Sādhanā*, 45(1), 1–18.
5. Mandal, I., **Kumar, V.**, & Saha, P. (2025). Machine learning prediction of erosion resistance of laser-clad coatings on martensitic stainless steel for steam turbine blades. *Journal of Micromanufacturing*, 1–9.
6. Singh, R., Chaudhary, A., & **Kumar, V.** (2025). Optimizing healthcare in the digital era: Fusion of IoT with other techniques. *EAI Endorsed Transactions on Internet of Things*, 11, 1–8.
7. Babbar, A., Jain, V., Gupta, D., **Kumar, V.**, Pathri, B. P., & Sharma, A. (2024). Medical imaging and analysis of thermal necrosis during bone grinding: Implementation of non-dominated sorting genetic algorithm (NSGA-III) in healthcare. *Current Medical Imaging*, 20(1), 1–23.
8. Solgi, P., Chenarani, M., Eivani, A. R., Ghosh, M., **Kumar, V.**, & Jafarian, H. R. (2023). Heat checking as a failure mechanism of dies exposed to thermal cycles: A review. *Journal of Materials Research and Technology*, 26, 865–895.
9. Sharma, A., **Kumar, V.**, Babbar, A., Dhawan, V., Kotecha, K., & Prakash, C. (2021). Experimental investigation and optimization of electric discharge machining process parameters using grey-fuzzy-based hybrid techniques. *Materials*, 14(19), 1–21.

10. Prakash, C., **Kumar, V.**, Mistri, A., Uppal, A. S., Babbar, A., Pathri, B. P., Mago, J., Sharma, A., Singh, S., Wu, L. Y., et al. (2021). Investigation of functionally graded adherents on failure of socket joint of FRP composite tubes. *Materials*, 14(21), 1–13.
11. Chakraborty, S., **Kumar, V.** (2021). Development of an intelligent decision model for non-traditional machining processes. *Decision Making: Applications in Management and Engineering*, 4(1), 194–214.
12. Chakraborty, S., **Kumar, V.**, & Ramakrishnan, K. R. (2018). Selection of the all-time best World XI Test cricket team using the TOPSIS method. *Decision Science Letters*, 8(1), 95–108.
13. Chakraborty, S., Das, P. P., & **Kumar, V.** (2017). Application of grey-fuzzy logic technique for parametric optimization of non-traditional machining processes. *Grey Systems: Theory and Application*, 8(1), 46–68.
14. Chakraborty, S., Das, P. P., & **Kumar, V.** (2017). A grey fuzzy logic approach for cotton fibre selection. *Journal of The Institution of Engineers (India): Series E*, 98(1), 1–9.

## EDITED BOOKS

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1. Iqbal, F., Gupta, P., **Kumar, V.**, & Pratihari, D. K. (Eds.). (2025). *Biomedical Robots and Devices in Healthcare: Opportunities and Challenges for Future Applications*. Elsevier. ISBN: 9780443222061. DOI: 10.1016/C2023-0-00581-7
2. Dey, S., **Kumar, V.**, Pratihari, D. K., Singh, V. P., & Islam, S. M. N. (Eds.). (2025). *Advancing Healthcare Through Decision Intelligence: Machine Learning, Robotics, and Analytics in Biomedical Informatics*. Elsevier. ISBN: 9780443264801. DOI: 10.1016/C2023-0-04801-9
3. Goyal, S. B., **Kumar, V.**, Islam, S. M. N., & Ghai, D. (2025). *Quantum Computing, Cyber Security and Cryptography: Issues, Technologies, Algorithms, Programming, and Strategies*. Springer Singapore. (In press). ISBN: 978-981-96-4947-1
4. Singh, R., Chaudhary, A., & **Kumar, V.** (2025). *Brain Signal Analysis: Fuzzy and Hybrid Computational Approaches*. Wiley. (In press)

## TECHNICAL SKILLS

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**Programming & Frameworks:** Python, C++, MATLAB, Jupyter Notebook, Google Colab

**IoT & Embedded Systems:** Arduino, ESP32, Raspberry Pi, Sensor Fusion (EMG, IMU, FSR), Real-Time Control

**AI/ML & Data Science:** scikit-learn (regression & classification), PyTorch, TensorFlow, SHAP, LIME

**Modeling & Simulation:** Finite Element Analysis (FEA)

**Computer Vision & CAM Techniques:** OpenCV, scikit-image, Vision Transformers, YOLOv8, Grad-CAM, Attention Maps

**Signal Processing:** EMG/Goniometer/IMU/FSR Data Analysis, Time-Series Forecasting, Statistical Testing

**Tools & Others:** Optimization & MCDM, Soft Computing, Research-Paper Writing.

## AWARDS AND ACHIEVEMENTS

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**RAAIBA-2022 Workshop (2022):** Attended Karyashala: High-End workshop on Recent Advances in Artificial Intelligence for Biomedical Applications (RAAIBA-2022) for 7 days, organized by NIT Rourkela, sponsored by SERB, DST, Govt. of India.

**Institute Assistantship (2021–present):** Ministry of Human Resource Development (MHRD) PhD Research Scholar, IIT Kharagpur.

**GATE Fellowship (2016–2018):** Graduate Aptitude Test in Engineering (GATE) Fellowship during M.E. at Jadavpur University, India.

## CERTIFICATION COURSES

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2020: Machine Learning (Stanford University, Coursera)

2020: Introduction to Robotic Process Automation, Artificial Intelligence, and Data Analytics (Simplilearn)

## EXTRA CURRICULAR

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**Equity & Mutual Fund Investing:** Personal interest in financial markets; actively manage a portfolio with long-term investments in **mutual funds**, **stocks**, and **IPOs**.

**Swimming:** Passionate about swimming; regularly pursue it as a recreational activity for fitness and stress relief.