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What the Peers Say!

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Dr. Ramana Vinjamuri is a leading innovator in brain-computer interfaces, neuroprosthetics, and human–machine interaction, with a distinguished academic journey spanning Kakatiya University, Villanova University, the University of Pittsburgh, Johns Hopkins University, and Stevens Institute of Technology, where he received the Harvey N. Davis Distinguished Teaching Award in 2018. Currently an Associate Professor of Computer Science and Electrical Engineering at UMBC, he also serves as the Center Director of the NSF Industry–University Cooperative Research Center (IUCRC) on BRAIN at UMBC, Visiting Scientist at the National Institute on Drug Abuse (NIDA), and Visiting Professor at the Indian Institute of Technology, Hyderabad and MAHE, Manipal, India. Dr. Vinjamuri is the recipient of the prestigious NSF CAREER Award, NSF IUCRC Planning Grant, and the Mary E. Switzer Merit Fellowship, and was recently recognized as one of Technical.ly's 2025 RealLIST Innovators in Maryland. His pioneering work integrates neural engineering, artificial intelligence, and rehabilitation technologies to create transformative solutions for human health and well-being. I am deeply honored to have the opportunity to interview him and gain insights from his remarkable contributions.

1. Origin

RJ: Greetings from *IJDMST*. It is a pleasure to interact with you on behalf of our readers. The purpose of this interview is to share the experiences of the peers in research and development, and also to show them the research needs and future trends. I am sure this interaction will benefit them a lot. Could you briefly share your academic and research journey in the United States and your collaboration with other countries?

RV: My academic journey began with a deep curiosity about how the human brain and body work in synchrony. After completing my MS at Villanova University, Ph.D. at the University of Pittsburgh and postdoctoral training at Pitt and Johns Hopkins University, I held faculty positions at Stevens Institute of Technology, where I received the Harvey N. Davis Distinguished Teaching Award in 2018. Currently, I am an Associate Professor at UMBC and serve as Center Director of the NSF Industry–University Cooperative Research Center (IUCRC) on BRAIN at UMBC. I also serve as a Visiting Scientist at the National Institute on Drug Abuse (NIDA), and a Visiting Professor at IIT Hyderabad and MAHE, Manipal, India, reflecting my strong U.S.–India academic bridge. Over the years, I have been fortunate to receive recognitions such as the NSF CAREER Award and most recently being named to Technical.ly's 2025 RealLIST Innovators in Maryland. International collaborations—whether in Portugal, Thailand, or India—have been key to shaping my vision for globally relevant neurotechnologies.

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2. Vision

RJ: What first inspired your pursuit of biomedical engineering, and how has your vision matured over the years?

RV: The seed of my interest was planted when I realized that technology could restore abilities lost due to injury or disease. Early in my career, watching patients with spinal cord injuries struggle for independence inspired me to ask: *How can engineering give them agency back?* My vision has since matured into not only developing technologies like brain-computer interfaces (BCIs) and neuroprosthetics, but also ensuring they are accessible, affordable, and scalable. Today, my vision is broader: to create human-centered neurotechnologies that integrate AI, rehabilitation robotics, and digital health ecosystems, enabling both clinical and everyday wellness applications.

3. Bridging Neuroscience and Engineering

RJ: Your research spans brain-computer interfaces, neuroprosthetics, and exoskeletons. In your view, what are the most transformative directions where engineering can bridge with neuroscience to empower human health and rehabilitation?

RV: The most transformative directions lie in closed-loop neuroadaptive systems—technologies that do not just record brain activity but also adaptively respond. For example, our work on HEXOES for stroke rehabilitation and for tetraplegia demonstrates how wearable controllers and intelligent exoskeletons can restore independence. Similarly, our novel earable ultrasound-based BMI platform, fuses brain, autonomic, and motion signals within an earbud, bridging neuroscience and engineering seamlessly. These technologies extend far beyond labs: they can empower people in their homes, workplaces, and communities.

4. AI–Neurotechnology Integration

RJ: Artificial intelligence and signal processing play a critical role in your work. Could you elaborate on how AI enhances brain-computer interface research and highlight a case where machine learning significantly improved system performance or usability?

RV: AI is the nervous system of modern neurotechnologies. In our Pneuma™ platform for stress and substance use disorder management, AI algorithms analyze multimodal signals—EEG, EDA, EMA—to detect stress patterns in real time. Traditional approaches could not handle such noisy, nonstationary data. By applying deep learning and transformer-based architectures, we improved accuracy from ~70%

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to over 90%, enabling meaningful neurofeedback and digital interventions. This leap shows how machine learning doesn't just improve performance, it makes the technology usable and clinically meaningful.

5. Translational Impact

RJ: Much of your research focuses on enabling practical neuroprosthetic and rehabilitation technologies. What do you see as the key factors that help research prototypes transition into clinically relevant or commercially deployable systems?

RV: Three factors are critical: clinical validation, business model innovation, and ecosystem partnerships. Prototypes succeed when tested rigorously in real-world clinical trials, supported by viable commercialization pathways, and integrated into care ecosystems. For example, through SBIR projects like HEXOES, Pneuma, and I-Corps interviews, we are mapping the value chain from lab to clinic. Equally important are partnerships—with hospitals, insurers, and rehabilitation centers—that accelerate adoption.

6. U.S.– India Research Synergy

RJ: With your academic contributions in the U.S. and your adjunct appointment at IIT Hyderabad, what unique opportunities do you see for strengthening U.S.–India collaborations in Deep Tech-driven healthcare innovation?

RV: U.S.–India collaborations are fertile ground for frugal innovation. India has immense clinical need and diverse patient populations; the U.S. offers advanced research infrastructure and commercialization pathways. Together, we can develop scalable, affordable healthcare technologies. For example, I envision global learning labs where U.S. and Indian students co-develop AI-driven rehabilitation tools, pilot them in diverse environments, and co-publish impactful findings. This synergy not only accelerates innovation but also builds a future-ready workforce.

7. Policy for Inclusive Neurotechnologies

RJ: In your opinion, how can brain-computer interfaces, prosthetic systems, and rehabilitation robotics be integrated into healthcare ecosystems to ensure accessibility, affordability, and scalability?

RV: Policy must encourage value-based innovation. That means not just funding high-end technologies but incentivizing affordable, modular, and scalable solutions. For instance, a prosthetic device may be too costly if imported, but local manufacturing and open-source software can bring costs down dramatically.

Integration into healthcare ecosystems also requires reimbursement pathways, clinician training, and digital health policies that support tele-rehabilitation. Inclusivity isn't just about lowering costs; it's about ensuring equitable distribution — from advanced hospitals in cities to rehabilitation centers in rural areas.

Policy must prioritize inclusive reimbursement models, open standards, and public–private partnerships. Without insurance coverage, even the most advanced devices remain inaccessible. Governments and NGOs can help by incentivizing adoption in rehabilitation centers and community hospitals. Moreover,

scalable tele-rehabilitation platforms—something we are piloting—can extend access to rural and underserved communities.

8. Emerging Deep Tech Trends

RJ: Which research areas in neural engineering, bio-signal processing or intelligent prosthetics do you feel remain underexplored and require more focused academic and industrial attention?

RV: I believe multimodal sensing — combining brain, physiological, and behavioral signals — remains underexplored. Most systems still rely on a single modality, like EEG, which limits reliability. Integrating signals such as electrodermal activity, ultrasound, or eye tracking with neural data could open new frontiers. Another underexplored area is emotional intelligence in assistive devices — technologies that respond not just to physical intent but to emotional state. Finally, regulatory science for neurotech lags behind innovation; we need more research into safety, ethics, and long-term deployment.

I also see one more underexplored frontier, Cultural-contextual neurotech – Most devices are designed for Western clinical contexts. There is a huge opportunity to design context-sensitive neurotechnologies for low-resource and culturally diverse settings, a theme I am exploring in U.S.–India collaborations.

9. Interdisciplinary Collaboration

RJ: Your work draws from electrical engineering, neuroscience, and rehabilitation medicine. How essential is such interdisciplinary collaboration in driving impactful breakthroughs in biomedical technologies?

RV: It is absolutely essential. No single discipline can solve the complexities of restoring human function. Electrical engineers bring tools, neuroscientists explain mechanisms, clinicians validate relevance, and entrepreneurs ensure scalability. I often tell my students: "Innovation happens at the edges, where disciplines overlap." My most rewarding projects have come from such intersections — whether working with neurologists on stroke rehab or with computer scientists on deep learning for EEG. Collaboration multiplies impact. My work—from prosthetics control to AI-driven stress monitoring—has thrived only because I collaborated with neurologists, physical therapists, psychologists, and computer scientists. True breakthroughs emerge at these intersections.

10. Relevance to DMST's Mission

RJ: What role do you believe journals like DMST can play in accelerating translational research and fostering global dialogue in Deep Tech for medicine?

RV: Journals like DMST can be bridges and amplifiers. They bridge gaps between engineering and medicine, academia and industry, developed and emerging economies. They amplify voices from diverse geographies, ensuring that deep tech solutions are shared globally rather than siloed. By curating translational research and fostering dialogue, DMST can accelerate the pipeline from lab discoveries to bedside solutions.

11. Research Areas for next 5 years

RJ: Looking ahead, what will be your primary research focus in the next five years, and how do you envision your work contributing to the evolution of brain-computer interfaces and human-centred healthcare technologies?

RV: Over the next five years, my primary focus will be on multimodal, human-centered neurotechnologies:

EUBMI: advancing earable brain-machine interfaces for daily wellness

Pneuma™: scaling multimodal stress detection for substance use disorder care

VR Hand Alphabets: gamified rehab and learning tools for stroke patients

HEXOES: wearable controllers and hand exoskeleton for mobility restoration

My aim is to move from proof-of-concept to clinical adoption, while training the next generation of innovators through the BRAIN Center. In short, my work will continue to shape a future where BCIs and neuroprosthetics are not exotic devices, but everyday healthcare tools.