Assistant Professor, Computing and data sciences, Flame University, Pune, India
Specializing in Haptics, HCI and VR/AR. I am an assistant professor with passion in adding the immersive Ness in Virtual reality and games. I have worked on various haptics projects: All type of tactile displays, Audio-tactile plugins, Virtual reality, Haptic gloves, navigation system using vibrotactile displays etc. I follow all the haptics conferences and Innovations in the scientific community of hapticians. I have published few papers in haptics journals and conferences and I hold a patent in haptics.

Dr. Rahul Kumar Ray, PhD

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Education

PhD with Touch lab, Applied Mechanics (Biomedical Engineering Group), IIT Madras, India GPA-8.4/10

Masters of Technology in Biomedical Engineering from NIT Kurukshetra, India (2015-2017) CGPA-9.67/10

Bachelors of Technology in Electronics Instrumentation and Control engineering from Govt. Engineering College Bikaner, India (2011-2015) Percentage- 76.66%

Skill Highlights

MATLAB, C/ C++, Python, Embedded Systems, Firmware development, RTOS, SPI/I2C, VR engine: Unity, C#, ROS, PCB Designing, Open CV, Image and Video Processing, Audio Systems

Hobbies

- Running, Cooking and Traveling

Research Highlights

- Interactive VR development, haptics and Audio systems
- Hand Tracking and Haptics Gloves design
- Tactile feedback systems: Electrotactile, Vibrotactile and Electrovibration
- Perceptual study with psychophysical methods for the combination of tactile displays.
- Haptics Illusions: out of the body funneling illusion
- Electrovibration: Designed an electrostatic display for textures perception and conducted psychophysical experiments

Experience (Technical)

- Hardware:
- Embedded systems Including SoCs (STM32MP157), Teensy, NRF
- Developed Haptic actuators, drivers and audio signal processing
- Experience with RP2040, ESP32 architecture and programming
- BareMetal programming and RTOS (Zephyr)
- Communication protocols (I2C, I3C, SPI, UART etc)
- Software:
- Virtual reality systems- Meta Quest 2 and HTC Vibe with Unity and C#
- Oculus Integration, hand tracking and interaction, real-time feedback in VR on the haptic Gloves
- GUI development using Python PYQT5
- Data analytics in R, Matlab and Excel
- Unity project with ROS to control a Robot's Arm

Experience (Professional)

- Assistant Professor, Flame University from May 2024
- Product Manager with Irerobot Ltd, Nicosia, Cyprus from July 2023 to April 2024
- Research Engineer with Compossible Umwelten Pvt Ltd, Mumbai from Jan 2023 to June 2023.
- Haptic Research Engineer in Loki team at INRIA Lille, France from Dec, 2021 to Nov 2022

Projects:

- ## Haptic Gloves (Irerobot Ltd, Nicosia, Cyprus)

  I worked with Irerobot ltd in Cyprus as a product manager on haptic gloves. We developed haptics glove with vibrotactile feedback and hand-tacking sensors. I managed a small team of engineers and working on electronics development and sensor fusion algorithms in unity as well. I developed the interactions of gloves, in virtual reality for several scenarios like game studio, medical training setup etc.

- ## Telerobotics in Virtual Reality

  I worked on a tele-robotics project in unity to control a remote robot in virtual reality. I developed a unity project to control the robot's arm following the hand tracking from meta quest.

- ## Multipurpose Haptic Device for rendering Haptics and Bio-signal Processing

  I worked in a startup based in Mumbai to design a haptic wearable which is capable of rendering tactile signals on a piezo actuator and an LRA. It senses Bio-electrical signals as well. I worked with the team on electronics for driver development and signal processing for bio-electrical signals. I am currently working with the firmware for this device and using embedded rust along with Zephyr. I have critically analyzed the communication protocols I2C, I3C, SPI etc. for data transfers.

- ## Haptic wearable for turn-by-turn navigation for cyclists

  I worked at INRIA Lille center under the Loki team with Dr. Thomas Pietrzak (https://www.thomaspietrzak.com/). We developed a hardware under INRIA startup studio program with a company (https://aureax.fr/) to provide haptic directional feedback for the turn-by-turn navigation for the cyclists. I developed hardware and designing user studies to validate the device. Device consists of vibrotactile actuators to provide the directional cues with a custom-made driver circuitry (capable of providing adjustable frequency, duty cycle and amplitude to 10 actuators).

- ## VR Project:

  Effect of scaling on human performance during micro tasks in VR environments: Considering 3D interactions in Virtual-Reality (VR), it is critical to study how visual awareness of real hands influences users' scaled interaction performance in different VR environments. HTC Vibe HMD was used along with hand controllers. Unity engine was used to create the scene and scripting was done using C#. We used Fitts's law to analyze user performance with five different Control-Display (CD) ratios (1:1 to 1:5). Fifteen participants performed a 3D selection task in three different setups: Head-Mounted Display (HMD) and two variations of the Active One-walled 3D Projection (AOP), with and without visual awareness of the real hand (AOP-A and AOP-B, respectively). The results show that the throughput of AOP-B is significantly higher than that of the AOP-A and HMD, which suggests the existence of a conflict between the kinesthetic and visual real-hand movements, which we term as Virtual Kinesthetic Conflict (VKC).

- ## Electrotactile Displays with Vibrotactile and thermal displays

  Effect of vibrotactile displays and different temperatures on the perception threshold of electrotactile displays was studied. We created the setup using basic electronics circuits and then conducted psychophysical studies to establish the relations. For electrotactile displays a function generator with adjustable frequency and duty cycle was used along with surface electrodes. Whereas for vibrotactile displays, we used LRAs along with haptic driver 2605 and an Arduino. For thermal displays, we used IR lamps along with a conical frustum to focus the heat at one point. The study suggested the reduction in threshold for electrotactile displays.

- ## Close Loop Blood Pressure Control System During Cardiac Surgery

  We collected arterial blood pressure data from the patients who were undergoing open heart surgeries. A fuzzy logic-based control system was designed to administer drugs from the automatic infusion pumps in order to control the arterial pressure. According to the suggestions from the

surgeons, we had to administer 4 different drugs, hence the logic was controlling the infusion of 4 pumps. The system was tested on patients in a cardiac operation theatre in the supervision of experts.

- **Measurement of Vibration using OpenCV in Python**

  I worked on a short project where I used a camera to record the video of a vibrating object. I fed the video into Program and analyzed the vibration on the surface of the object. The coding was done in Python and OpenCV tools were used for tracking and calculations.

- **Electrovibration: Design and Psychophysical Study**

  I am currently working towards designing tactile feedback systems in the screens (visual displays) in order to provide texture feedbacks in the online shopping and different human-computer interactions in virtual reality. I'm using electrostatic displays to generate the frictional forces on the display when a finger is scrolled on it. After designing the electronic systems and interfacing with capacitive touch displays, I'm exploring the possibility of threshold reductions using different methods which are under publication.

Research Outputs

- Journal papers:
  1. Patel Payal, Rahul Kumar Ray, and Muniyandi Manivannan. "Power Law Based "Out of Body" Tactile Funneling for Mobile Haptics." *IEEE transactions on haptics* 12.3 (2019): 307-318. https://doi.org/10.1109/TOH.2019.2933822
  2. Rahul Kumar Ray, Payal Patel, and M. Manivannan. "Reduction of Electrotactile Perception Threshold Using Subthreshold Vibrotactile Stimuli." *Displays* (2021): 102056. https://doi.org/10.1016/j.displa.2021.102056
  3. M Balasubramanian, J.K., Ray, R.K., Manivannan," Effect of Subthreshold Electrotactile Stimulation On The Perception of Electrovibration" ACM transactions on Applied Perception (2023): https://doi.org/10.1145/3599970
  4. Ray, Rahul Kumar, Madhan Kumar Vasudevan, and M. Manivannan. "Electrotactile displays: taxonomy, cross-modality, psychophysics and challenges." Frontiers in Virtual Reality 5 (2024): 1406923. https://doi.org/10.3389/frvir.2024.1406923
- Conference Papers:
  1. Madhan Kumar Vasudevan, Rahul Kumar Ray and Manivannan Muniyandi (2020) Computational Model of a Pacinian Corpuscle for an Electrical Stimulus: Spike-Rate and Threshold Characteristics. EuroHaptics 2020. Lecture Notes in Computer Science, 12272, 203-213 https://link.springer.com/chapter/10.1007%2F978-3-030-58147-3_23
  2. R.K. Ray, M. Manivannan, Spatial summation of electro-tactile displays at subthreshold, in Human Interaction, Emerging Technologies and Future Applications IV, Springer Inter-national Publishing, Cham, 2021, pp. 463–470. https://link.springer.com/chapter/10.1007/978-3-030-74009-2_59
  3. Rahul Kumar Ray, and M. Manivannan. "Reduction of Electrotactile Perception Threshold using Background Thermal Stimulation." 5th International conference on Human Interactions and Emerging Technologies. https://link.springer.com/chapter/10.1007/978-3-030-85540-6_42
  4. M Balasubramanian, J.K., Ray, R.K., Manivannan," Effect of Subthreshold Vibration on the Perception of Electrovibration", HAID 2022 https://link.springer.com/chapter/10.1007/978-3-031-15019-7_4#author-information
- Patent Filed:
  1. Patent filed on, "Method of constructing Hybrid tactile Displays", International patent application Number: WO 2020/222252 A1 https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2020222252

References

1. Dr. Thomas Pietrzak
   Affiliation: University of Lille, INRIA Loki team in Lille, France ; email: thomas.pietrzak@univ-lille.fr; contact: +33 (0)3 59 35 87 86 (https://www.thomaspietrzak.com/)
2. Dr. Manivannan M
   Affiliation: Professor, Applied Mechanics and Biomedical Engineering, IIT Madras, Chennai, India. Email: mani@iitm.ac.in,Contact Number: 944927022
3. Dr, Evagoras Xydas
   Affiliation: Assistant Professor, Frederick University and CEO, Irerobot Ltd, Nicosia, Cyprus. Email: evagoras.xydas@irerobot.com, contact: +357-99644287