Yu-Chun Ku

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EDUCATION

Johns Hopkins University, Baltimore, MD **Sep. 2022 – June 2024**

Master of Science in Robotics

- **Selected Coursework:** Augmented Reality, Robot System Programming, Robot Device Kinematics Dynamics and Control, Algorithms for Sensor-based Robotics, Computer Integrated Surgery, Machine Perception

National Taiwan Normal University, Taipei, Taiwan **Sep. 2016 – June 2020**

Bachelor of Mechatronic Engineering

- **Selected Coursework:** Machine Learning, Intelligent Automation and Robot, Artificial Intelligence

RESEARCH INTERESTS

My research interests are creating intelligent computer-assisted systems that integrate **Digital Twins**, **Robotics**, and **Foundation Models** to transform healthcare and surgical interventions. I aim to: 1) develop high-fidelity digital twins that simulate surgical environments for optimizing workflows and supporting decision-making, 2) create intelligent robotic systems toward autonomous surgery, and 3) use foundation models to improve multimodal data processing, such as combining medical imaging and procedural knowledge to create intelligent systems.

PUBLICATIONS

1. J. Wang, J. A. Barragan, H. Ishida, J. Guo, **Y. Ku**, et al.: A Digital Twin for Telesurgery under Intermittent Communication. *The 2025 International Symposium on Medical Robotics.* In Review.
2. H. Zhang, B. D. Kileen, **Y. Ku**, et al.: StraightTrack: A Mixed Reality Navigation System for Percutaneous K-wire Insertion. *Wiley Health Technology Letters, 2024. Special Issue: MICCAI AE-CAI 2024.*
3. **Y. Ku**, et al.: Evaluating the Effectiveness of Visual Guidance for Out-of-View Object Localization using Mixed Reality Head-Mounted Displays. *Present as poster in The 23rd IEEE International Symposium on Mixed and Augmented Reality.*

RESEARCH EXPERIENCE

Mixed Reality Platform for Scalable Robotic Data Generation **Dec. 2024 – Present**

Isaac Sim, Unity3D *Johns Hopkins University*

- Designed an MR platform to enable teleoperation and scalable and high-quality ego-centric robotic data generation
- Integrated with NVIDIA Isaac Sim for realistic physics-based simulations and high-fidelity dataset creation
- Leveraged hand-tracking and inverse kinematics to enable real-time robot control and movement visualization

Room-Scale Digital Twin Simulation for OR Workflow Analysis **Sep. 2024 – Present**

SAM2, Python, Digital Twins — **Advisor:** Prof. Mathias Unberath *Johns Hopkins University*

- Creating object-level 3D digital twins of operating rooms for workflow analysis
- Generating annotated datasets of 14 instruments and 15 procedural phases to enhance instrument and phase detection
- Applying foundation models to extract features across 38 cases of video frames for accurate scene reconstruction
- Designed an annotation pipeline with a GUI for Segment Anything Model 2 to streamline segmentation and labeling

Teleoperation with Communication Loss on da Vinci Surgical System **Sep. 2024 – Nov. 2024**

dVRK, ROS, Python — **Advisor:** Prof. Peter Kazanzides *Johns Hopkins University*

- Developed a digital twin framework for the da Vinci surgical robot to maintain teleoperation functionality during communication loss using a virtual environment in the AMBF simulator
- Conducted a user study with 8 participants performing the peg transfer task 2 experimental conditions (baseline and replay), analyzing NASA TLX results to show reduced frustration and smoother task performance
- Revealed that the replay strategy reduced task completion time by 23% and improved workflow recovery
- Findings submitted for review to **PUBLICATIONS #1**

High-Fidelity Virtual Reality Clinical Training System **June 2024 – Present**

Unity3D, C#, Neuralangelo — **Advisor:** Prof. Vinciya Pandian & Prof. Mathias Unberath *Johns Hopkins University*

- Developed a standalone VR system to simulate the central line dressing change procedure for clinical training
- Generated digital twin assets of medical environments and instruments using neural surface reconstruction techniques
- Implemented a sequential control mechanism to guide users through each procedural step accurately
- Designed a user study with healthcare professionals to evaluate the training effectiveness of the VR environment

Mixed Reality-Assisted Trajectory Planning and Guidance System **June 2024 – Aug. 2024**

Optical Tracking, 3D Printing — **Advisor:** Prof. Mathias Unberath *Johns Hopkins University*

- Developed an MR system on HoloLens 2 for percutaneous orthopedic K-wire placement, achieving an average placement accuracy of 5.26 mm and 2.88°
- Integrated real-time instrument tracking and spatial alignment to minimize errors and improve insertion accuracy
- Collaborated with 2 experienced surgeons to evaluate system performance using custom 3D-printed phantom models
- Published findings in **PUBLICATIONS #2**

Evaluating Effectiveness of Visualization Techniques in Mixed Reality **Sep. 2023 – Mar. 2024**

User Study Design — **Advisor:** Prof. Alejandro Martin-Gomez *Johns Hopkins University*

- Explored visualization methods to enhance localization of out-of-view objects on HoloLens 2, using Just Noticeable Difference (JND) to quantify perceptual thresholds
- Designed a user study with 24 participants, testing 3 MR techniques (3D Arrow, 3D Radar, EyeSee360) in 2 user interface modalities (dynamic, static)
- Revealed 3D Arrow as the most effective for rapid object identification, while 3D Radar and EyeSee360 offered distinct advantages in spatial encoding and panoramic awareness
- Published findings in **PUBLICATIONS #3**

RELEVANT PROJECTS

AI-Assisted Patient Navigation using Mixed Reality **Apr. 2024**

RAG, LangChain — Healthcare Hackathon with AI (H2AI) *Georgetown University*

- Built a virtual assistant for health providers and patients, enabling patient navigation using AI-embodied Mixed Reality
- Developed a device-agnostic, multi-agent, and MR-enabled system that provides remote clinical access, intuitive visualization, expert knowledge management, and online decision-making
- Built web scrapping components for actual local health provider data and expert knowledge

Augmented Reality-Enhanced Surgical Microscopes for Spinal Procedures **Jan. 2024 – May 2024**

Unity3D, C#, Python, NDI *Johns Hopkins University*

- Developed an AR system using for real-time 3D anatomical visualization in Minimally Invasive Spinal Surgery
- Implemented real-time anatomy tracking and registration to digital twin using NDI tracking system
- Created a Unity plugin that enabled real-time marker-based detection and pose estimation using OpenCV

WORKING & TEACHING EXPERIENCE

Johns Hopkins University **Aug. 2023 – May 2024**

Teaching Assistant, Augmented Reality *Baltimore, MD, USA*

- Guided teams through advanced AR projects such as the development of a campus tour navigation system on mobile devices and surgical guidance interfaces for continuum manipulators

DiJet Link Co., Ltd. **Sept. 2020 – May 2022**

Full-Stack Software Engineer *Taipei, Taiwan*

- Led the development of case management and reporting web platforms, phasing out paper-based systems by using PostgreSQL and Laravel PHP
- Designed and maintained robust databases, optimizing data schemas and reducing redundancies to enhance reporting and data processing workflows
- Developed dynamic front-end interfaces using Vue.js, improving user experience with reactive components and efficient two-way data binding
- Built a Node.js web system for monitoring underground water levels, incorporating time series data management and Python algorithms for precise data analysis

TECHNICAL SKILLS

- **Programming Languages:** C++, C#, Python, MATLAB, JavaScript
- **Frameworks/Tools:** ROS, Unity3D, PyTorch, TensorFlow
- **Web Development:** Node.js, Express.js, Django, React, Vue.js, PostgreSQL, MongoDB