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Toward Dexterous Aerial Manipulation using Embodied Human-Intelligence for Bridge Inspection and Maintenance

Dongbin Kim
University of Nevada, Las Vegas

INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

INSPIRE University Transportation Center Webinar

Toward Dexterous Aerial Manipulation using Embodied Human-Intelligence for Bridge Inspection and Maintenance

2022-03-16



Dongbin Kim's Brief Intro.

2016
WEST Internship at UNLV
Ministry of Education, Korea
US Department of State
(Honored Student Awardee)

2017 to 2021
Ph.D. Student at UNLV
Lab Manager at DASL
Topic : Aerial Manipulation

Accomplishments

- 11 Publications in International Conferences (IEEE, ISARC, IWSHM)

- "Skywriting Unmanned Aerial Vehicle Proof-of-Concept Design", IEEE International Conference on Unmanned Aircraft Systems (ICUAS), 2017.
- "Lab Automation Drones for Mobile Manipulations in High Throughput Systems" , IEEE International Conference on Consumer Electronics (ICCE), 2018
- "Lab Automation Drones for Mobile Manipulations in High Throughput Systems", Society of Lab Automation and Screening (SLAS), 2018
- "Towards Micro-Plate Delivery using a re-sized Lab Automation Drone in High Throughput Systems", IEEE International Conference on Ubiquitous Robots (URAI), 2018
- "Toward Lab Automation Drones for Micro-plate Delivery in High Throughput Systems", IEEE International Conference on Unmanned Aircraft Systems (ICUAS), 2018
- "A New UAV-based Module Lifting and Transporting Method: Advantages and Challenges", International Symposium on Automation and Robotics in Construction (ISARC), 2019
- "Testing-and-Evaluation Platform for Haptic-based Aerial Manipulation with drones", IEEE American Control Conference (ACC), 2020
- " Human-Drone Interaction for Aerially Manipulated Drilling using Haptic Feedback", IEEE International Conference on Intelligent Robots and Systems (IROS), 2020
- "Toward Avatar-Drone: A Human-Embodied Drone for Aerial Manipulation", IEEE International Conference on Unmanned Aircraft Systems (ICUAS), 2021. **(Served as session chair for UAV Application I)**
- "A Human-Embodied Drone for Dexterous Manipulation in Bridge Inspection and Maintenance", International Workshop on Structural Health Monitoring (IWSHM), 2022 (Accepted)
- "Aerial Manipulation using Embodied Human-Intelligence", IEEE International Conference on Advanced Robotics and its Social Impacts (ARSO), 2022 (Submitted)

Accomplishments

- Invited Talk (SLAS)

- Society of Lab Automation and Screening (SLAS) (2018), UNLV CEE 710 Modular Construction (2021), Chonnam University, Korea (2022), University of Hartford (2022), West Point Military Academy (2022)

- Award

- Best Presentation Award – First Prize, 2021 Annual Meeting of US Department of Transportation, INSPIRE University Transportation Center
- 2018 Society of Lab Automation and Screening (SLAS)
  - Innovation Award Finalist, Tony B. Student Award

- Patent

- U.S. Provisional Patent(filed with UNLV), "An Object Manipulator a

- Conference and Journal reviewer (IEEE)

- IEEE Robotics and Automation Letters (RA-L)
- Journal of Intelligent and Robotic Systems (JINT)
- Mechatronics
- IEEE International Conference on Robotics and Automations (ICRA)
- IEEE International Conference on Intelligent Robots and Systems (IR
- IEEE American Control Conference (ACC)

- Teaching Experience – ME 337L (TA), ME 421L (TA), ME4

GRADUATE STUDENT POSTER SESSION

INSPIRE UTC graduate students from all consortium institutions attended the annual meeting. Participating students interacted with transportation professionals from the government and industry sector. A Graduate Student Poster Session was held, and offered students the opportunity to showcase their research, communicate results to other students, faculty and staff, engage with representatives from the transportation industry, and facilitate interdisciplinary work by exchanging knowledge and ideas between individuals from multiple disciplines.

POSTER SESSION GUIDELINES

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MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

First Place Award

PRESENTED TO

Dongbin Kim

In recognition of outstanding achievement in the 2021 Annual Meeting Graduate Student Poster Competition
sponsored by INSPIRE University Transportation Center

MISSOURI S&T

Genda Chen, Ph.D., P.E., F.ASCE, F.SEI, F.ISHMII
Director, INSPIRE University Transportation Center

INSPIRE

Dongbin Kim-First Place Winner

UNLV

DASL
Drones and Autonomous Systems Lab @ UNLV

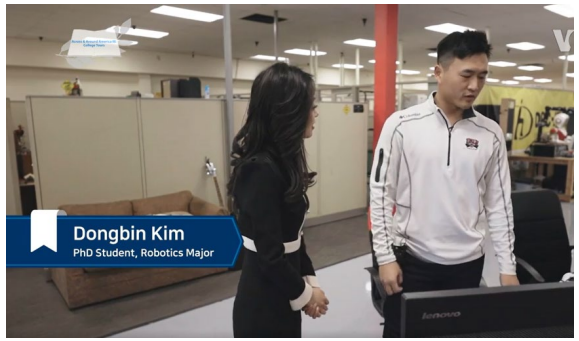
Accomplishments

- Promoting UNLV Robotics Program

DRC-Hubo demo for local high school (2017)

Lab Tour for Gibson MS robotics Team (2018)

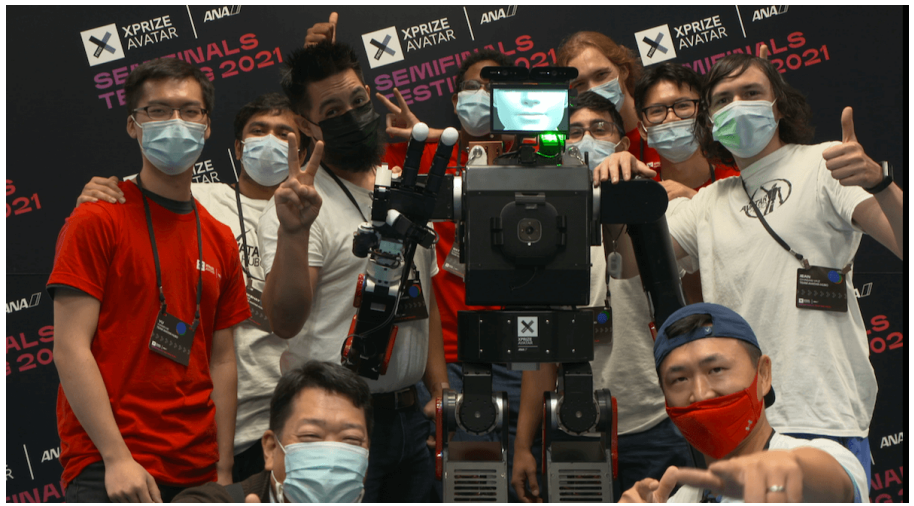
Amazon RE:MARS (2019)



Voice of America - Korean – College Tours (2020)

Chief of Architect – IEEE International Conference on Intelligent Robots and Systems (IROS) On-Demand platform (2020)

NASA-STTR Phase I Research Assistant under Dr. Woosoon Yim (2021)



$10M prize, ANA AVATAR XPRIZE Competition Logistic Lead (2021)

Motivation

Motivation | Research Needs/Objectives/Questions

Inspecting and Preserving Infrastructure through Robotic Exploration (INSPIRE)

U.S. Department of Transportation

- Natural disaster risks ↑
- 50% of national bridge approach their design life
- Project **goal**: Development of advanced sensing and robotic technologies for infrastructure inspections and preservation solutions

Recent issue of the current practice in Bridge Inspection/Maintenance

- Blocking the traffic
- Difficulty in access to bridge structures
- Dangerous field activities

DASL
Drones and Autonomous Systems Lab @ UNLV

DASL@UNLV in INSPIRE Project

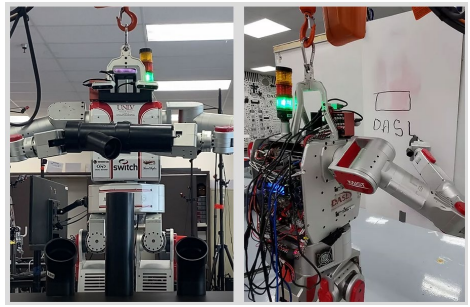
- DASL@UNLV: One of 11 University Collaborators
- Key role: A **drone for aerial manipulation** in **bridge inspection and maintenance**

Notional Concept for Embodiment


Expert Workers

VR/AR Devices

Embodiment



Bridge Work Site

Social Interaction

Assist

Tasks At Hazardous sites

Methodology

UNLV

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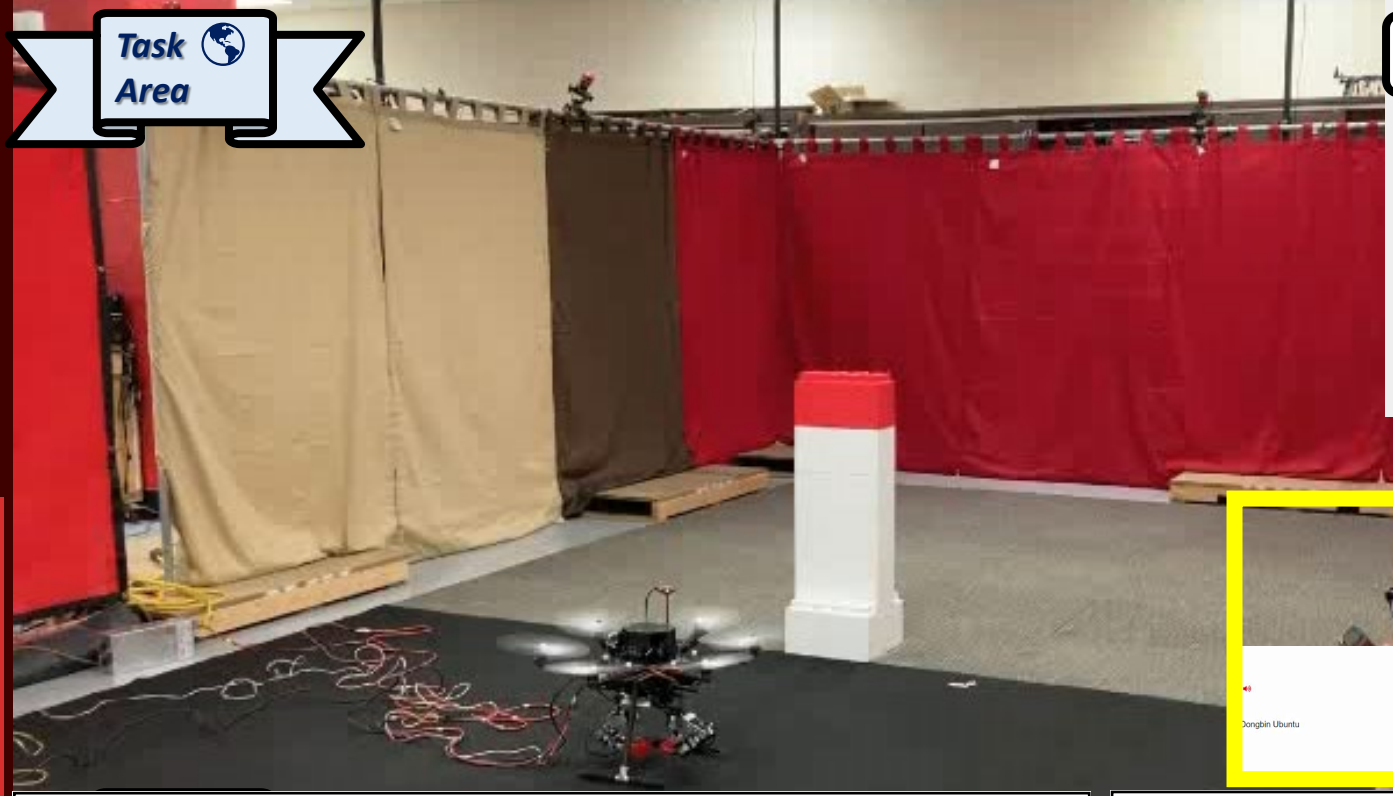
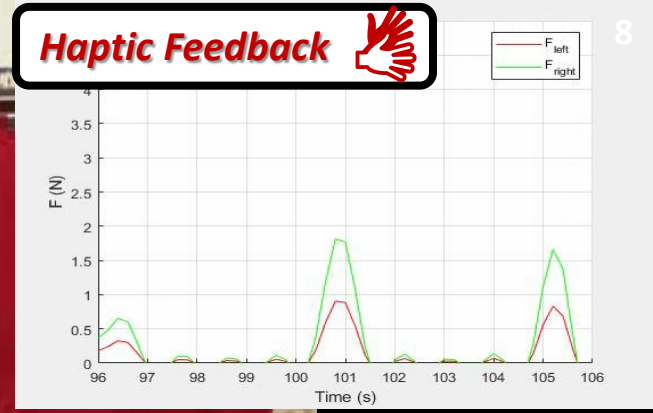
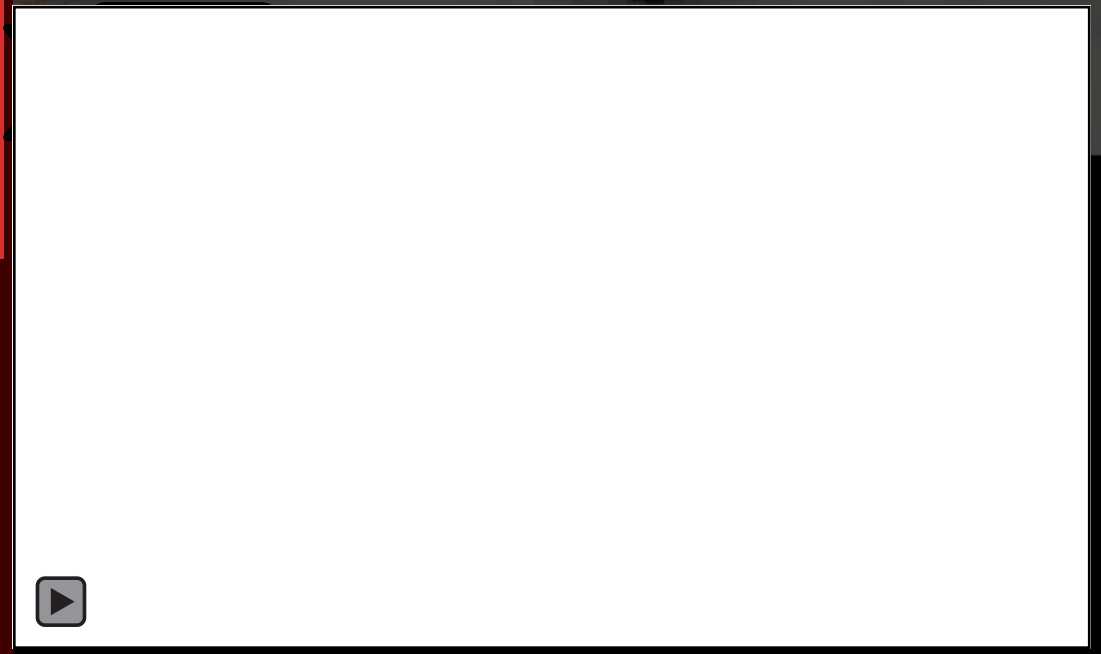
Scenario

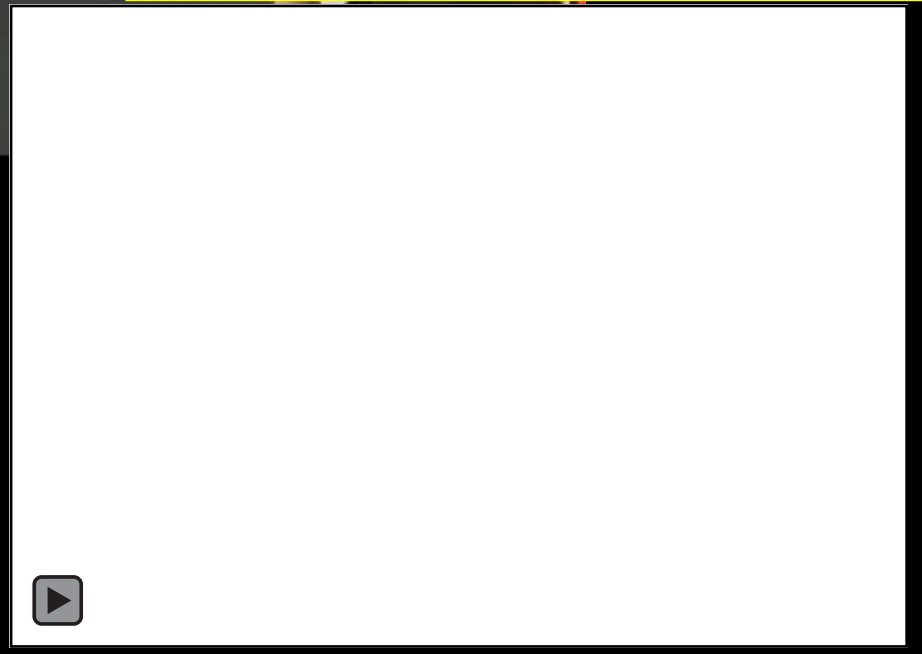
Package delivery

With Voice Communication



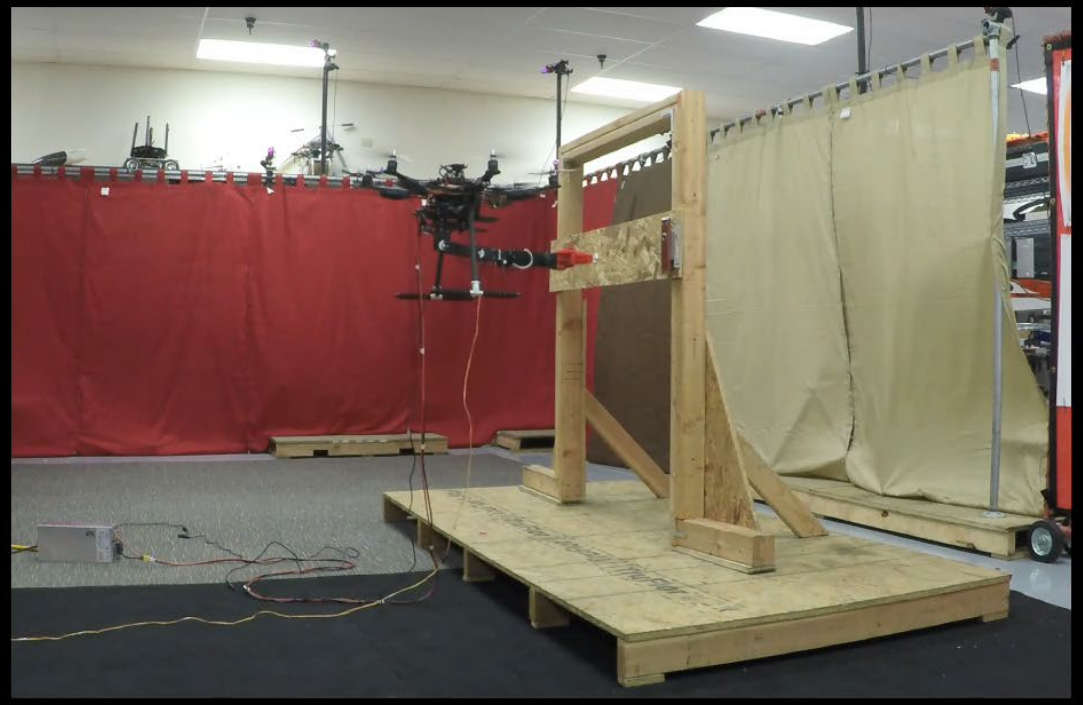






Scenario #3

Key Manipulation



UNLV DASL
Drones and Autonomous Systems Lab @ UNLV

Conclusion

Contribution

- "***Embodiment***" of the user for dexterous aerial manipulation
- Pick-and-place, Peg-in-hole, Drilling, and Key manipulation has been accomplished

Conclusion and Future Work

- Human-embodied drone interface provides suitable motion trajectories for mobile robot
- New gaps: Forward/Inverse Kinematics doesn't represent Human's arm motions (Correspondence problem)
- Research on Impedance/stiffness on Human body motions

Concluding Mark

- Human-embodied drone interface may accelerate autonomous mobile manipulation
- Human-embodied interface simulates real world environment -> Hardware free task training systems
- Human-embodied robots -> Bring new opportunities for people outside of normal life boundaries

Acknowledgement

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Thank You

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