Human Collaborative Haptic-based Mobile-Manipulating UAVs

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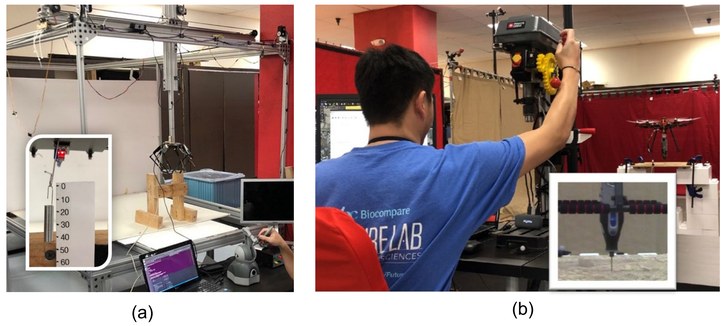
INTRODUCTION

Current drones *passively surveil*. Drones equipped with robotic limbs and grippers shifts this paradigm with *active interaction*. This would be needed to robotically enhance bridge-related work. Called aerial dexterous manipulation, drones could hose decks; prep surfaces; and epoxy cracks.

The net effect is a flying robot that *works on the environment* rather than simply sensing it. Such research is important to advancing bridge maintenance and repair.

Research gap: worker experience is rarely integrated in the design of such field and service robots. For bridge-related tasks, such experiences includes tool settings like: cutting bit size; tool feed rates and direction; and spindle speeds



(a) (b)

Fig 1: (a) shows Testing-and-Evaluation platform for haptic-based aerial manipulation, and (b) describes a proof-of-concept for human collaborative haptic-based aerial manipulation to perform surface work (Drilling)

METHODS

Give bridge worker:

Haptic Interface: the sense of touch to remotely operate tools attached to the drone

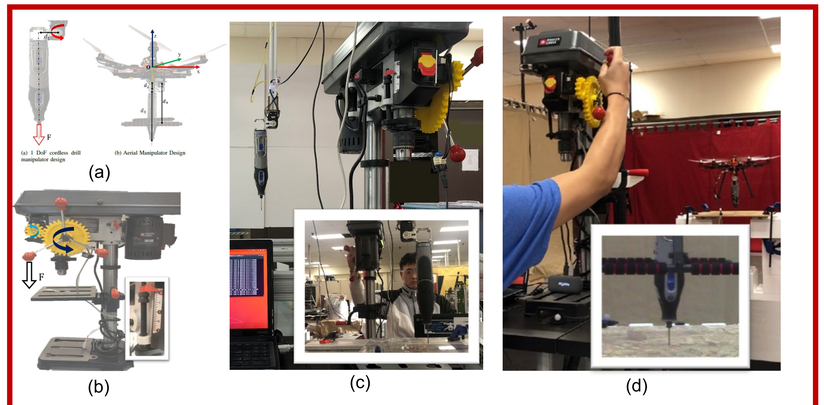
Augmented Reality (AR) Headset: a visual immersion into the remote work site

Test-and-Evaluation (T&E): Gantry-based system (**Figure 1 left**) to measure performance of the drone-manipulator, haptic feedback, and AR cues.

Verification-and-Validation (V&V): Flight tests in motion-capture arena to ensure performance metrics are met.

RESULTS

A robotic limb that carries a drill was mounted on a rotorcraft drone. A modified off-the-shelf drill press (**Figure 2**) served as the haptic interface. The key result was that the operator could remotely feel drill-workpiece contact forces.



(a) (b) (c) (d)

Fig 2: (a) Haptic Drill Arm, (b) Customized Haptic Drill press, (c) Test-and-Evaluation platform, (d) Flight trials

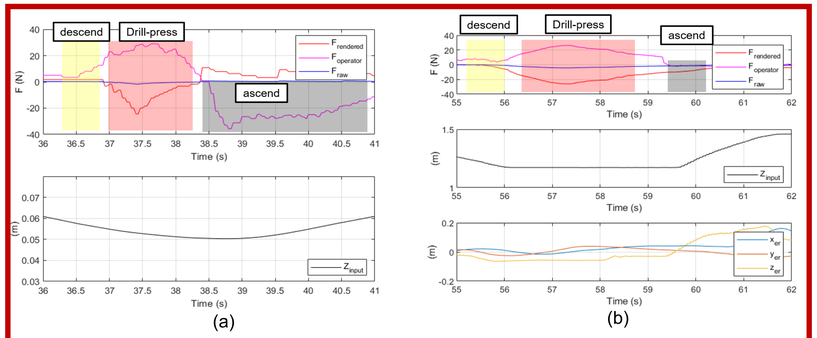


Fig 3: Aerially manipulated drill task - (a) Test-and-Evaluation platform result, (b) Flight trials result

T&E and V&V results in Figure 3 successfully captured drill-workpiece contact forces. With these forces, the user was able to remotely drill through a variety of materials (e.g. wood and acrylic), of various thicknesses, and rates.

CONCLUSIONS

V&V flight trials demonstrated the efficacy of the T&E gantry; remote drilling using the haptic interface worked in both cases showing similar performance data.

Future work: Avatar-Drone

Based on the promising results of the haptic-based approach, plans include adding Augmented Reality for both visual and acoustic immersion (**Figure 4**).

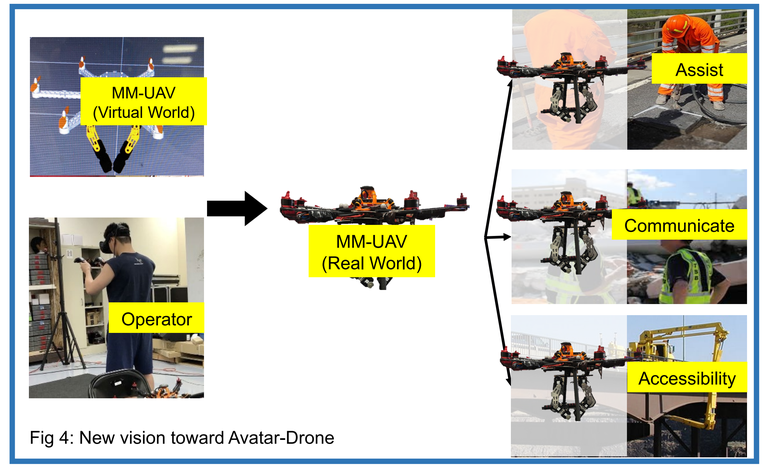


Fig 4: New vision toward Avatar-Drone

Avatar-Drone would embody the operator to mobile manipulating drone in both the physical and virtual worlds. This would give bridge workers an interface to accelerate maintenance and repair tasks.

REFERENCE

- D. Kim, P. Oh, “Testing-and-Evaluation platform for Haptic-based Aerial Manipulation with drones,” IEEE American Control Conference (ACC), July, 2020
- D. Kim, P. Oh, “Human-Drone Interaction for Aerially Manipulated Drilling using Haptic Feedback,” IEEE International Conference on Intelligent Robots and Sytsems (IROS), 2020 (Accepted)

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