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Sky Writer: Sketch-Based Collaboration for UAV Pilots and Mission Specialists

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Sky Writer: Sketch-Based Collaboration for UAV Pilots and Mission Specialists

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ABSTRACT
Sky Writer is a collaborative communication medium that augments the traditional display of a UAV pilot and allows other stakeholders to communicate their needs and intentions to the pilot. UAV pilots engaging in time-critical missions, such as urban disaster responses, often must allocate most of their cognitive capacity towards flight tasks, making communication and collaboration with other stakeholders difficult or dangerous. Sky Writer addresses the needs of stakeholders while requiring minimal cognitive effort from the UAV pilot. The application presents stakeholders with an interface that provides contextual flight information and a live video stream of the flight. Stakeholders are able to sketch directly on the video stream or use a spotlight indicator that is mirrored across all displays in the system, including the pilot's display. The application can be used in any modern web browser and works with traditional and touch devices. Concept experimentation performed at Disaster City with two pilots indicated that the spotlight feature was particularly useful while the UAV was in motion, and the sketching features were most useful while the UAV was stationary. The system will be tested with professional responders soon to determine its efficacy in a simulated response, and to inform the ongoing design process.

Categories and Subject Descriptors
I.2.9 [**Robotics**]: Operator Interfaces

Keywords
Unmanned aerial vehicles; sketch interface

1. INTRODUCTION


Figure 1. The AirRobot 100-B with its controller.

An important challenge facing UAS teams (composed of a pilot, mission specialist, and safety officer [1]) is conveying information from the various stakeholders to the pilot in a non-disruptive, but informative manner. Figure 1 shows a traditional UAV system, composed of the UAV and the pilot's hand controller. Prior work has enabled stakeholders to have a visual common ground with the pilot by giving them their own dedicated display that mirrors what the pilot sees [2]. Sky Writer extends upon that by enabling the stakeholder to visually convey information to the pilot via sketches and spotlight annotations on the video stream. Additionally, this work adds flight context information, like live mapping, to the stakeholder's display, providing them with more data to inform their directions to the pilot. Finally, Sky Writer is executed in a modern web browser, allowing mirrored displays to be easily deployed to additional stakeholders, who can then see the mission in real time and provide annotation input of their own.

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2. INTERFACES


Figure 2. The pilot's interface.

Sky Writer augments the traditional display of the UAV pilot with an interface that can display annotations input by mission stakeholders. Mission stakeholders can use either a sketching feature or a spotlight feature to communicate their needs to the pilot. The system can support several users collaborating on the same flight at a time while ensuring real-time delivery of annotations to both local and remote users. Figure 2 shows the pilot's interface, which can be physically located near or over the original UAV controller.

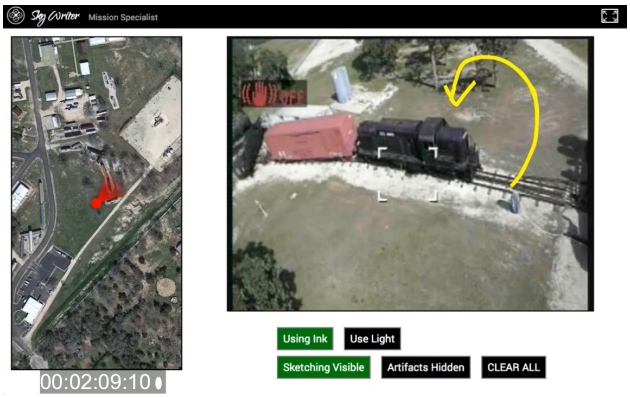

Figure 3. Sketching on the stakeholder's interface.

The sketching feature (Figure 3) allows users to directly draw on the UAV's video stream. These drawings are pushed to all connected devices, including the pilot's display. This enables mission stakeholders to draw symbols like arrows or circles to indicate areas of interest or communicate intentions such as a rotate symbol. All users of the system may input sketches simultaneously, while viewing other user's sketches in real-time as they are drawn.

The spotlight feature (Figure 4) works by dimming the video feed in all but the areas of the screen being touched or clicked on by a user. The system supports an unlimited number of spotlights simultaneously, which may come from multi-touch input on a single device, or from a combination of devices and users. The spotlight feature is particularly useful because the light is only active while the user's finger or mouse is down, and tracks with their movement in real-time.

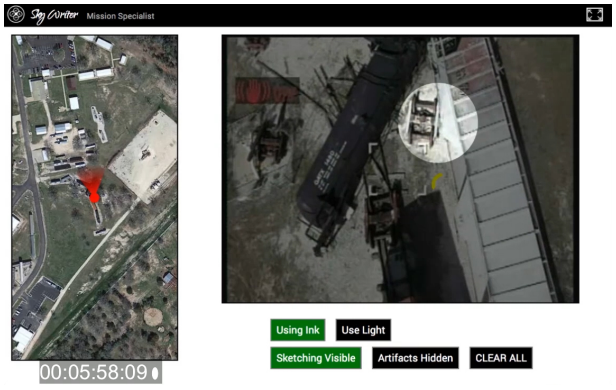

Figure 4. Using the spotlight feature on the stakeholder's interface.

Sky Writer includes two separate interface designs, one for the UAV pilot and another for mission stakeholders. While the UAV pilot's interface is designed to mimic the UAV's original display with augmentations for annotation data, the stakeholder interface provides both flight context information and a video stream.

The pilot's interface mirrors the UAV's traditional display in order to provide familiarity and reduce cognitive burden on the pilot. The interface is dominated by the UAV video feed with artifacts and bordered by a few control options. The buttons include the option to clear the annotations, disable collaborative annotations, and the ability to toggle flight data artifacts. The interface can be run on any device that has a modern web browser. Initial inquires were conducted using a 7-inch consumer tablet. Additionally, testing was conducted with the Sky Writer display placed slightly above the UAV's controller display (Figure 5).

Figure 5. The pilot operator control station with Sky Writer tablet mounted on original controller.

The stakeholder's interface includes the same video feed as the pilot's with the same sketch and spotlight overlays, along with buttons to clear the screen, disable sketching, and display video artifacts. The stakeholder can also select between using sketching and using the spotlight feature. The stakeholder inputs annotations by touching or clicking on the video feed. Additionally, the stakeholder's interface presents a map with satellite imagery of the area, and an icon representing the UAV's position and heading. The interface can be run on any modern web browser. Initial inquiries used a 10-inch consumer tablet.

Sky Writer works on both the local network near the UAV deployment and on remote networks if an internet connection is available. This enables real-time collaboration with remote experts.

3. EARLY LESSONS

Early field trials of the Sky Writer interface at Disaster City with two UAV pilots illustrated the ability of the pilot to fly the UAV, while simultaneously observing sketches and spotlight cues input by other stakeholders. Though the pilot was also given the ability to sketch on the collaborative display space, testing showed that pilots preferred to verbally acknowledge visual cues, giving them the ability to maintain hands-on control of the UAV. The spotlight feature was found to be particularly useful, as it did not obscure any of the video feed and team members were able to actively track objects they were interested in, even when the video shifted vantage points. Additionally, testing provided evidence that gestures indicating desired actions like zooming or rotating would be a useful feature. In the tested implementation the team relied on verbal communication to clarify requests for these actions. Initial reviews also suggested that a brief one minute guided tour of the interface's functionality, using a simulated UAV flight, would assist first time users in understanding the abilities of the system.

4. WORK IN PROGRESS

Work in progress includes extending the functionality to include gesture support and a guided interface tour. The system will also be tested with responders and other experts to evaluate the interface in a simulated disaster response.

5. ACKNOWLEDGEMENTS

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