Mini-UAV User Interface Elements: Trade-offs and Validation

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In the Wilderness Search and Rescue (WSAR) domain, it is desirable to allow a single operator to use a camera-equipped mini-UAV to perform a search task. In military domains, which typify current approaches, searching is commonly decomposed into two separate operations: pilot and payload operator. Allowing a single operator to perform both jobs requires changes in craft autonomy and interface design. We hypothesize that appropriately designed autonomy and interface can enable efficient task completion by simplifying the management of UAV autonomy and by reducing mental workload to allow time for critical decision-making.

We have developed a prototype interface intended for a single, dismounted operator. We are conducting a series of experiments using this interface to accomplish three goals: (a) refining the interface, (b) validating features of the interface for WSAR, and (c) exploring a set of design tradeoffs. In this presentation, we will discuss several tradeoffs involved in designing an interface to allow a single, dismounted operator to perform both pilot and payload operator roles. Specifically, we will address (1) the effect of camera angles on the efficiency of search and control, (2) methods for supporting perception of the video stream, and (3) effects associated with different levels of control and information presentation. We will identify key tradeoffs and present preliminary experimental evidence to support design choices.

Camera angle. Two tradeoffs dominate the placement of a camera. First, there are tradeoffs between fixed cameras and gimbaled cameras. The former supports robustness, light weight, and simplicity of camera control; the latter supports flexibility and simplicity of UAV flight path control. Second, there are tradeoffs between forward and downward facing cameras. The former supports understanding and controlling the UAV and the latter supports maximum image detail. Between these extremes are angles that may provide a "sweet spot" in the tradeoff space for a particular type of search.

Video presentation. In practice, a target may pass through the video frame very quickly. We are exploring various options for supporting human memory and perception, particularly when the human operator must simultaneously be pilot, payload operator, and team member. The key issue is the contextual presentation of the video signal. The primary tradeoff is between a chase perspective, which uses the horizon as the frame of reference, and a top-down perspective, which uses a map as the frame of reference; see the Figures below. A secondary tradeoff is deciding how much map and terrain information to include with the video. Using a model should decrease mental workload, but it can introduce distortion or confusion. These tradeoffs are confounded by the type of autonomy, from fully manual to fully autonomous control.

Information presentation. Information besides video must be communicated to facilitate UAV control. However, presentation of relevant but minor information and control options can hinder decision making by distracting the operator or overshadowing more important factors. We are studying the tradeoffs that accompany the inclusion of various types of information: some must be present, some are salient but secondary, and some can be discarded for simplicity.

Figure 1 Forward facing camera

Figure 2 Downward facing camera

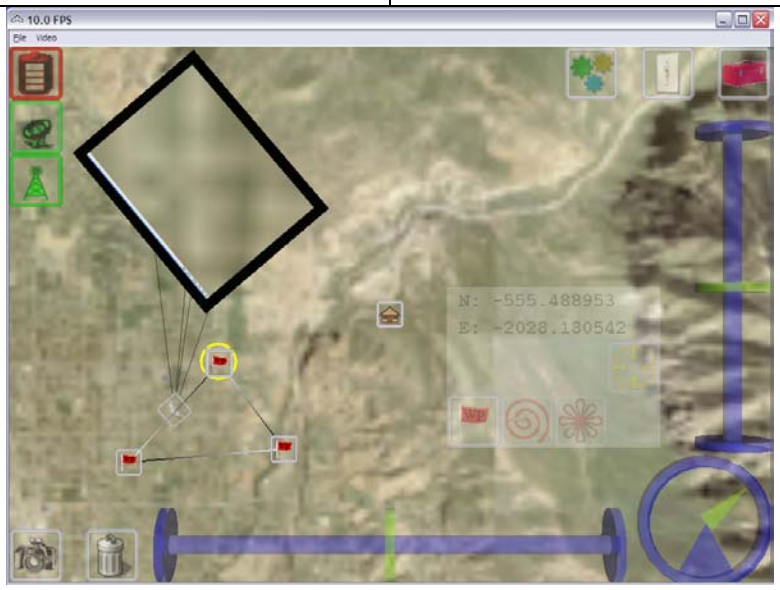

Figure 3 Map-centric perspective