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Urban Search and Rescue with Canine Augmentation Technology

Alexander Ferworn[1], Alireza Sadeghian[1], Kevin Barnum[2],
Hossein Rahnama[1], Huy Pham[1], Carl Erickson[1], Devin Ostrom[3], Lucia Dell'Agnese[4]

[1] Network-Centric Applied Research Team, Department of Computer Science, Ryerson University
[2] Provincial Emergency Response Team, Ontario Provincial Police
[3] Department of Mechanical Engineering, Ryerson University
[4]Department of Fashion, Ryerson University

Abstract - *The agility, sense of smell, hearing and speed of dogs is put to good use by dedicated canine teams involved in Search and Rescue operations. Perhaps the weakest link in the human-dog team is the human. In comparison to dogs, humans hear less, cannot effectively follow a scent and actually slow the dog down when involved in area searches. To mitigate this problem the Network-Centric Applied Research Team has been working with the Ontario Provincial Police to augment SAR dogs with a suite of supporting technologies to extend the dog's potential area of operation and allow a greater distance between dog and handler. Through Canine Augmentation Technology we hope to allow canine handlers to see what the dog sees, hear what the dog hears, know where the dog is and be able to communicate with the dog at extended distances.*

Keywords: Search and Rescue, SAR, USAR, Canine Augmentation Technology

1 Introduction

This paper discusses a novel system that augments canine Search and Rescue (SAR) teams with technological components that allow closer cooperation between a SAR dog and its handler. The system allows greater separation between the dog and handler and is applicable where obstruction precludes the use of direct voice or hand signals.

The paper begins with a brief introduction to SAR and the use of canine teams, discusses related animal augmentation efforts and goes on to explain how technological components might be applied to enhance SAR and especially urban SAR (USAR) cooperation between dog and handler. Finally, experimental results from various field trials are presented.

2 Search and Rescue

Search and Rescue operations are mounted by emergency services personnel to find people in distress who may be lost, sick or injured. Often these operations take place in remote and difficult to access areas (Fig.1). Increasingly, however, searches take place in urban areas. For the most part, speed is of the essence as the target of a search is often in physical danger.

Many tools and techniques have been employed to find people including a plethora of camera and other sensing systems and, most recently, robots [1, 2]. While promising as rescue devices, in many situations, the logistics and technical limitations of robotic systems often make them unsuitable for use in situations requiring rapid search in difficult environments--commonly found in USAR operations.

Fig. 1. USAR training Rubble Pile in Toronto

3 Canine Teams

In many cases the fastest and most effective means of finding live casualties while searching is through the use of specially trained canine teams [3] consisting of a handler and one or more dogs. Many breeds of dogs are well suited to the search task. They have keen senses of smell and hearing, excellent agility and — with the right temperament

— can be trained to search for and indicate the locations of casualties.

The City of Toronto Police Services report that over 70% of operations involving canine search are conducted "off leash" and start in large open areas [4]. Canine teams work closely together, using the behavior of the dog and the guidance of the handler to effectively search an area. However, when the area is large and with many structures—some of which might be reduced to rubble, the progress of the search is often slowed by the inability of the human handlers to keep up with their dogs.

3.1 Canine Teams and CAT systems

Like many canine search and rescue organizations, the Ontario Provincial Police (OPP) has organized their canine resources to maximize their effectiveness [5]. We are currently working with several of these teams to provide technological components that will be carried by the dog and handler to provide interaction capabilities between them even when they are not within audio or visual contact.

We refer to this system as Canine Augmentation Technology (CAT) and it will eventually encompass a wide variety of integrated communication resources. The conceptual model of the CAT system is depicted in Fig. 2 below.

Fig. 2. The conceptual model of the CAT system

Handlers will receive video, audio and GPS streams from their dogs and, under certain circumstances, the dogs will receive the handler's voice commands through a specially designed harness. All communication will take place over a peer-to-peer network established between the dog and handler. The "dog" components of the system are based around the notion that all the subcomponents of the system must function in the challenging environment imposed by USAR operations.

The CAT system has taken its inspiration from a number of initiatives in many different communities to increase the benefits provided by service and companion animals.

4 Animal Augmentation

The technological augmentation of animals has been spurred by a plethora of motivations. The United States Navy employs specially trained and equipped bottlenose dolphins in harbor de-mining operations [6]. Camera-equipped animals have been widely used for research and entertainment [7]. Perhaps because dogs have been employed as service animals for so long, they have received special attention.

Technologically augmented dogs were employed at the World Trade Center disaster to help SAR personnel. SAR dogs had small wireless cameras attached to their collars. The dogs would squeeze into openings in the rubble to search inside cavities for survivors [8]. A similar camera system called FIDO is in use by police forces in the United Kingdom for surveillance purposes in weapons seizure operations [9].

5 Preliminary Experimental Results

We have conducted five trials of various CAT prototypes and concepts. Our initial trials concentrated on video stabilization techniques. There are many trade-offs in a dog-mounted camera system. Our first trial made use of a FIDO dog-camera harness that proved adequate when the dogs were stationary (in the sitting or down positions) but quite unstable when the dogs were in motion. A newer prototype, shown in the figure below, employs a modified "Halti" collar and proved to be much more stable.

As the camera is mounted on the dog's head, much more strapping is required to hold the camera in place. This has proven to be quite a problem when the dogs are involved in rubble searches. It is possible for the harness straps to get hooked by bits of metal or rebar, trapping the dog and forcing the handler to free the dog. We are working on versions of the system that will integrate break-away

features into existing collars to allow the dog to escape if the harness becomes entangled.

Fig. 3. The modified *Halti* collar

Our work has also concentrated on providing voice communication to the dog from the handler. Again, mounting the apparatus on the dog has proven to be very challenging. We have experimented with various speaker systems and have determined that the SAR dogs are very aware of the fidelity of the voice communication coming from their handlers.

There are many issues we are exploring related to the frequency response of the system speakers on the dog and how they are to be positioned for effective voice transmission. The results of our trials have shown that it is possible for a handler to issue remote voice commands to the dog and the dog will obey them. One of our early prototypes mounted on the SAR and cadaver dog "Dare" with both the camera and speakers is shown in Fig. 4 on the right.

Fig. 5 depicts a modified FIDO harness with high-fidelity earphones mounted over and behind the dog's ear flaps. This device proved to be a failure as our test dog would not obey any commands relayed through it. This was surprising since the same speaker elements proved very successful in a previous trial. Clearly, more experimentation is required with the dogs in conditions they will actually experience.

Our later trials concentrated on using the prototype CAT systems under operational conditions in rubble piles and low brush associated with USAR operations.

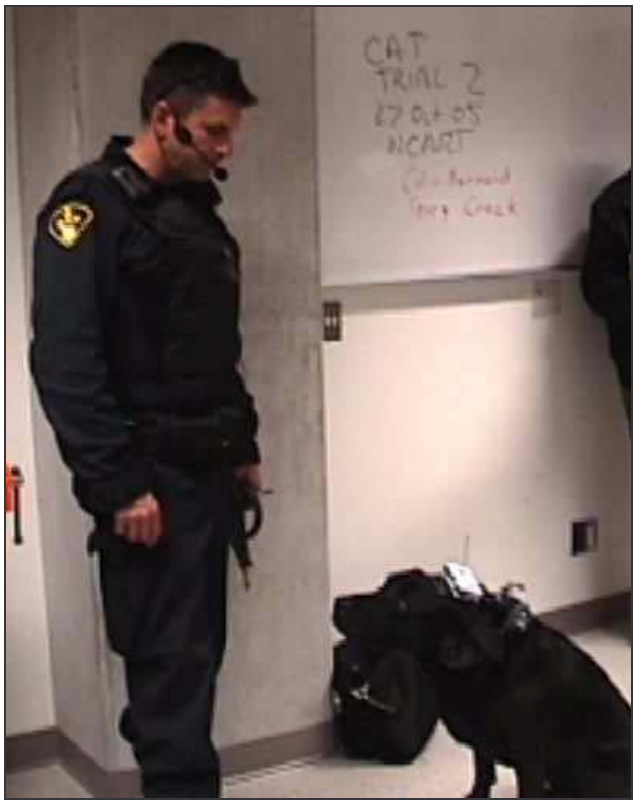

Fig. 4. An early CAT prototype on an OPP SAR dog

Fig. 5. A modified *FIDO* harness with ear phones

Fig. 6. CAT transceiver prototype as carried by handler

Several test scenarios were devised that placed simulated casualties at various locations within low brush and rubble. SAR dogs were equipped with various CAT prototypes and their performances were evaluated.

Fig. 7 was taken from one of our prototype system's video streams. The SAR dog "Moose" was given the task of finding a casualty within a 200 meter radius that was hidden in a debris field of low brush and rubble. The figure shows the moment "Moose" found the casualty. The efficacy of the system was demonstrated because the handler only saw the casualty through the system's video display and even after the Moose indicated the casualty's presence, they could not be seen from outside the brush.

Fig. 7. A simulated casualty video frame from camera mounted on the dog

6 Lessons Learned

Much has been written concerning training dogs for SAR operations and very effective methods have been developed for their deployment [10]. Our testing of the CAT system has indicated that handler-dog communication can be greatly enhanced through the use of integrated, light-weight communication components but they do not mitigate certain canine characteristics that can only be overcome with training with a working complete prototype. For example, certain commands can no longer be issued by the handler with any meaning. "Come here" means nothing to the dog when the handler cannot be seen. Many handlers use hand signals or similar physical indications of direction. Saying "left" or "right" to the dog has no meaning without training.

There are also many technical issues that present challenges of their own. Providing voice commands with the appropriate fidelity and reliability under operational conditions is quite difficult--but possible. The need for reliable wireless network communication becomes critical as loss of communication between the dog and handler could result in confusion for both the dog and its handler and lengthen the time of search, putting the casualty at greater risk.

There are also ergonomic issues associated with mounting CAT on a SAR dog. Because the process of searching is very active, video stability is important if the handler is to interpret what is happening around the dog. The video stream tends to be more stable when it is taken from on top of the dog's head but only certain SAR dogs will tolerate such a head-hardness and the added strapping can easily become entangled with protruding components within the search area. We are currently working with an industrial clothing designer to mitigate this problem.

7 Conclusion

We have started an investigation into the use of integrated communication technology within existing Canine SAR teams. The CAT system provides the potential for Canine teams to work more closely together despite being at greater distances and allow the canine handler to experience what the dog experiences.

Personnel involved in SAR operations have shown reticence in adopting new and often unproven technological solutions to problems that they believe can be overcome through training or simpler means. Essentially they have used a "if it isn't broken, don't fix it" approach to adopting new technology. By continuing to test our CAT systems with operational SAR canine teams, we hope to introduce a

working set of systems that also have the acceptance of its eventual user community.

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