

Real-Time Biological Target Detection in Operation Environments by Dogs

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The Need

Dogs are a deployable and mobile sensor that can be used in a wide variety of environmental conditions and operational settings, humanitarian assistance, stability operations, natural disasters and other emergency response needs by conventional forces and Special Operations. The DoD's use of dogs is perhaps best known as explosive-sniffing canines deployed to detect improvised explosive devices buried in the field. [1] However, utilizing dogs in other roles, such as for mobile real-time detection of biological targets, would benefit the DoD in a variety of other missions, including CBRNE detection, industrial chemicals, pollution, and illicit substances, as well as acting as a medical sensor for human and animal diseases. This article highlights the use of dogs in operational environments.

The Target

Pathogen infection by natural disease outbreak is the leading cause of death worldwide in plants, animals and humans. In addition, bioterrorism is a serious threat to world populations and food sources. Scientists have been investigating technologies that aid in early detection of pathogens to prevent the spread of natural disease outbreak and bioterrorism activities. Recent advancements in analytical chemistry demonstrate that pathogen infections

produce unique volatile organic profiles or odors.

Production of cellular volatile organic compounds occurs in millions of cells simultaneously, thus releasing extracellular VOC on a detectable scale. These VOC enter the blood stream and release into the air around a human, animal or plant. The mechanism of the release is through breath, urine, feces, skin emanations and blood. [2] The VOC profile of an individual reflects their health status and provides a sample to use for diagnostic purposes.

The Concept

One overlooked, but highly capable, technology for the real-time detection of unique pathogen VOC profiles is detection dogs. Dogs are a mobile real-time detection technology that are the gold standard in operational environments for detection of explosives, narcotics, accelerants, people, animals and other targets of interest.

Dogs possess five essential qualities for biological detection in operational environments: (1) extreme analytical sensitivity in the parts per trillion range; (2) real-time discrimination of complex odor profiles; (3) ability to trace an odor to its source; (4) the ability to efficiently search large areas and populations for a biological target; and (5) the ability to sample in environmental extremes, including high particulate densities in the air.

Dogs possess 220-300 million sensory receptors

which allow them a lower limit of detection at concentrations of one part per trillion. [3] A sensitivity of one part per trillion is three orders of magnitude more sensitive than today's available instruments. In addition, the dog has tremendous mobility and capabilities to efficiently search large areas and trace odor to its source. This capability could increase an operational team's ability to quickly find biological targets in crops, livestock and human populations.

Operationally, dogs should be considered a supportive technology to other sensory platforms and instruments, where dogs are used in a queuing process, enabling initial detection of target substances, or when scanning of large numbers of humans, animals or inanimate objects is necessary.

Strategically, the dogs would be used in conjunction with existing or future developed electronic devices that may be mandated by regulation, or used as stand-alone real-time mobile sensors, where detection limits exceed the sensitivity of current technology or the stand-off distances prohibit the use of currently available detection technology. Researchers at Auburn University are currently working to develop the strategies and techniques of using dogs in combination with existing detection equipment, labeling the process, "Dog Assisted Detection."

The Hurdle

A current hurdle in the use of dogs to detect highly virulent pathogens is the manufacturing of safe training aids. Dogs need to

train on pathogen-associated odors, which means that these odors need to be safely trapped and released for training purposes. Such as technology would be especially important for highly contagious pathogens capable of infecting humans and dogs. For other pathogens, cell cultures and other methodologies could be utilized.

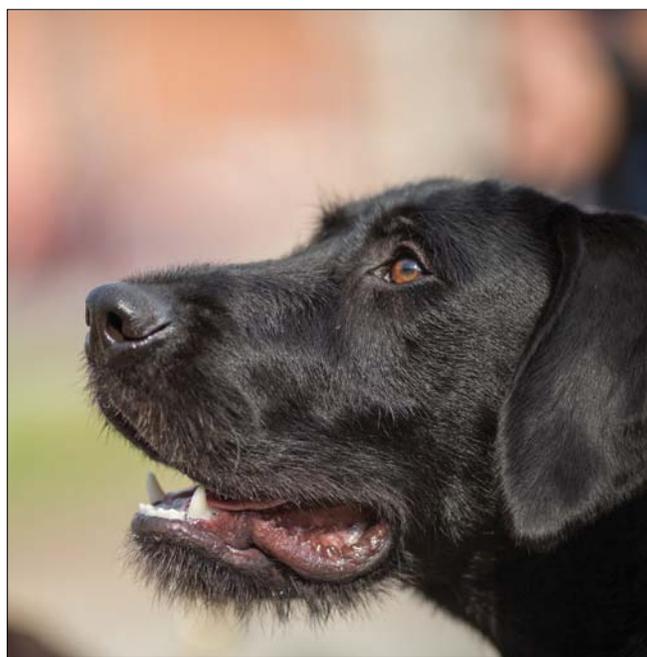
The Capability

Detection dogs have previously been demonstrated to successfully detect a variety of biological targets with relatively high diagnostic accuracy. Dogs have demonstrated the ability to detect cancer by sampling breath, feces, urine, blood, and tissue. Researchers trained a dog to detect colon cancer using samples of exhaled breath (sensitivity, 91 percent; specificity, 99 percent) and watery stool (sensitivity, 97 percent; specificity, 99 percent). [4]

Another study demonstrated the overall sensitivity of canine scent detection of lung cancer and breast cancer utilizing exhaled breath samples was 99 percent, with a specificity of 99 percent for lung cancer and 88 percent and specificity was 98 percent for breast cancer. [5] A dog was trained to detect *C. difficile* with high diagnostic sensitivity and specificity in stool samples and

hospitalized patients, correctly identifying 25 of the 30 *C. difficile* cases and 265 of 270 control cases. [6]

A recent study demonstrated that dogs could detect bovine viral diarrhoea virus and discriminate it from bovine herpes virus 1 and bovine parainfluenza virus 3. [7] The diagnostic sensitivity and specificity in that study was 85 percent and 96 percent and 98 percent and 99 percent, for each of the two dogs respectively. The above studies illustrate that dogs have the sensory capability to detect pathogens in real-time. Future research needs to evaluate whether dogs can detect pathogen-associated VOC in operational environments just like they have done for decades in explosives, narcotics, human tracking, search and rescue, arson and other targets of interest. If dogs can prove to



Auburn University's Canine Performance Sciences Program is training dogs such as this one to detect explosives, narcotics and other targets of interest. (Released)

be real-time mobile pathogen sensors in operational environments then there are many force-multiplier roles they can play for a variety of operational missions.

References

1. Frankel, R. (2014, October 31). *Military Dogs Sniff Out IEDs, Save Lives*. Retrieved April 14, 2016, from <http://www.wsj.com/articles/military-dogs-sniff-out-ieds-save-lives-1414772453>
2. Amann A, Costello B, Miekisch W, Schubert J, Buszewski B, Pleil J, Ratcliffe N, Risby T. *The human volatilome: volatile organic compounds (VOC) in exhaled breath, skin emanations, urine, feces and saliva*. *J. Breath Res* (2014) 8, 034001. doi:10.1088/1752-7155/8/3/034001.
3. Walker, D.B., Walker, J.C., Cavnar, P. J., Taylor, J.L., Pickel, D.H., Hall, S.B. & Suarez, J.S. (2006). *Naturalistic quantification of canine olfactory sensitivity*. *Applied Animal Behaviour Science*, 97, 241-254.
4. Sonoda H, Kohnoe S, Yamazato T, Satoh Y, Morizono G, Shikata K, Morita M, Watanabe A, Morita M, Kakeji Y, Inoue F. *Colorectal cancer screening with odour material by canine scent detection*. *Gut* (2011) 60:814-819. doi:10.1136/gut.2010.218305
5. McCulloch M, Jezierski T, Broffman M, Hubbard A, Turner K, Janecki T. *Diagnostic accuracy of canine scent detection in early- and late-stage lung and breast cancers*. *Integr Cancer Ther* (2006) 5:30-39. doi:10.1177/1534735405285096
6. Bomers MK, van Agtmael MA, Luik H, van Veen MC, Vandenbroucke-Grauls CMJE, Smulders YM. *Using a dog's superior olfactory sensitivity to identify Clostridium difficile in stools and patients: proof of principle study*. *Br Med J* (2012) 345, e7396, doi:10.1136/bmj.e7396
7. Angle TC, Passler T, Waggoner PL, Fischer TD, Rogers B, Galik PK, Maxwell HS. *Real-Time Detection of a Virus Using Detection Dogs*. *Front Vet Sci* (2015) 2:79. doi:10.3389/fvets.2015.00079

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