USING AN ARTIFICIAL DOG NOSE TO LEARN HOW CANINES DETECT EXPLOSIVES AND NARCOTICS

Matthew Staymates, William MacCrehan, Jessica Staymates, Brent Craven, and Greg Gillen

Abstract

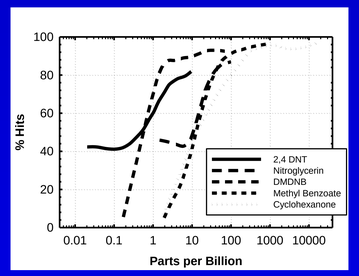
An investigation of the external aerodynamics of canine olfaction is presented. Extending upon the previous work done by Settles (2002) and Craven (2010), we have developed an anatomically-correct artificial dog nose. The nose is modeled from detailed MRI imaging of a female Labrador Retriever and fabricated using a 3D printer and sniffs with realistic flow rates and frequencies. Flow visualization experiments using schlieren imaging enable real-time examination of the dogs remarkable ability to attract and sample vapors from extended distances. During exhale, a turbulent air jet emanates from each nostril and entrains fluid from ahead of the nose, sometimes at a distance of many tens of centimeters. This vapor is now readily available for inhalation, during which the nose now acts as a potential-flow inlet. During active sniffing, this exhale/inhale cycle is repeated at a frequency of around 5Hz. We have learned that the dog is an *active* aerodynamic sampling system, utilizing fluid dynamics to increase its aerodynamic reach to sample vapors at increasingly large distances.

We are in the process of measuring the differences in performance characteristics of a dog that sniffs regularly vs. a dog that could inhale only. These measurements require the development of unique vapor-collection and LCMS chemical detection techniques to evaluate the collection of trace vapors associated with the detection of TNT via aerodynamic sampling. As a form of biomimicry, we are now utilizing bio-inspired design principles from the dog and applying them to optimize current- and next-generation vapor sampling technology.

Canine Olfaction Background

- Canines are considered the gold standard in trace chemical sampling
- Sensitivity is comparable to instrumental systems, however sample collection, signal processing and analysis, and cycle times are almost instantaneous

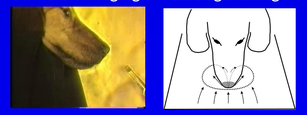
✓ Tracking people – criminals, search/rescue operations
✓ Law enforcement – narcotics and explosives
✓ Arson – accelerants vs. combustion by-products
✓ Medical – cancer/melanomas
✓ Physiological – epileptic seizures



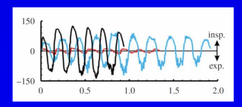
(Johnston, Waggoner et al., Auburn University)

Previous Work – Fluid Dynamics of Canine Olfaction

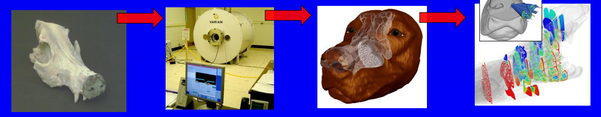
Schlieren imaging of real dog sniffing



Settles, et.al. *Airborne Trace Sampling: Lessons Learned from the Dog's Nose*. 2010 Annual Workshop on Trace Explosives Detection, Baltimore, April 2010



Craven, et.al. *The fluid dynamics of canine olfaction: unique nasal airflow patterns as an explanation of macrosmia*. J. R. Soc. Interface (2010) **7**

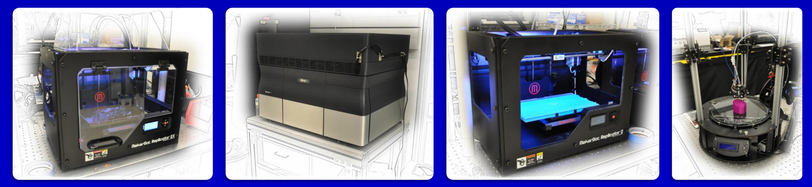


Craven, et.al. *Reconstruction and Morphometric Analysis of the Nasal Airway of the Dog and Implications Regarding Olfactory Airflow.* The Anatomical Record 290 (2007)

External Canine Olfaction

The world's first anatomically-correct actively-sniffing dog's nose

Printed on a variety of 3D printers

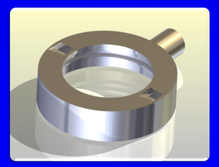


Schlieren imaging used to visualize canine olfaction

The dog is an *active* aerodynamic sampling system, using turbulent air jets to entrain fluid from ahead of itself.

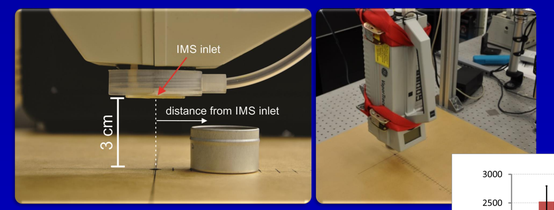
What's the point? -- Biomimicry

Once we learn how nature does things, can we apply it to technology being developed now, or help optimize the current generation of COTS equipment?



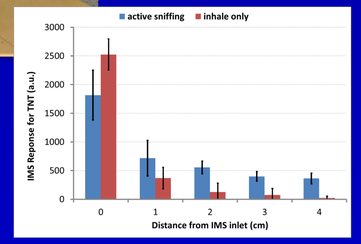
Designed and printed "nostrils" for COTS vapor detectors

Vapor Sampling Experiments

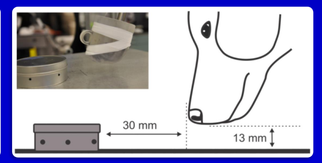


- 30 mm height
- 10 sec sampling time
- Varying distance from inlet
- Open can with TNT gelatin as the vapor source

Experiments suggest a factor of 5 improvement in aerodynamic reach. Only location with inhale being larger is at distance zero, because exhaling air is pushing sample away from detector inlet.

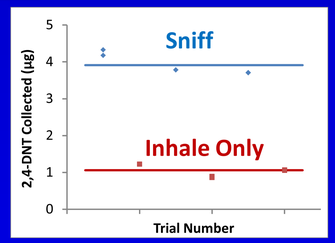


Quantitative Vapor Sampling and Collection



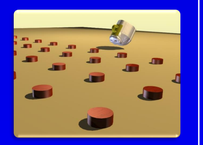
- Polyurethane Foam (PUF) insert
- DNT vapor source
- 30 mm standoff distance
- 20 min sampling time
- 65 LPM peak-to-peak sniffing
- 46 LPM RMS inhale only

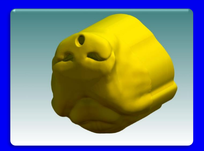
Experiments show a factor of 4 increase when the dog is sniffing vs. inhale only. During inhale, the dog nose acts as a potential flow inlet (with minimal aerodynamic reach). Exhaling air jets act to augment this limited reach via fluid entrainment.

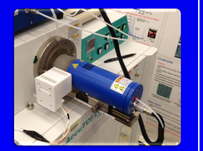


Summary and Next Steps

- Artificial dog nose is more cooperative than a real dog in a schlieren system
- Jet-assisted sniffing (active) is used by the dog to augment potential flow inhale, thus increasing the aerodynamic reach for vapor a particle sampling
- We can optimize/improve COTS vapor detectors using biomimicry
- Next-generation samplers may benefit from bio-inspired design principles
- 2-dimensional measurements to map aerodynamic reach
- DART interface for real-time measurements of vapor collection
- New sniffing mechanisms/front-ends for other vapor-based detectors







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Questions? Email: matthew.staymates@nist.gov