# Controlled Olfactory Delivery using Magnetophoretic Guidance

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**Introduction**: Direct nose-to-brain drug delivery has many advantages over the intravenous delivery approach. The major challenge in achieving clinically significant nose-to-brain drug delivery is delivering drugs to the olfactory region. We propose to increase the olfactory delivery efficiency by using magnetic guidance.

Limitations of normal magnetic control:
1. Field and gradient decay quickly in space.
2. Unstable: too weak at far, too large when near.

**New thought and Rationale:**
A nonmagnetic particle within a ferrofluid will experience a repulsive force; Stable control

Analogy: a lighter object experience a buoyance force in a heavier fluid.

The idea is inspired by several seemingly irrelevant phenomena when they met and fused together. Figure 1 speaks a thousand words on how they can connect.


**Figure 1**. Building Magnetic track for olfactory drug delivery.

**Study Design**:
1. Test magnetic track in a 2-D channel.
2. Test magnetic track in human nose cavity.

**Methods**:
1. Four COMSOL modules used: fluids, electromagnetic, particle tracking, optimization.
2. Parameter of interest: magnet layout and strength, drug resale position, particle diameter, geometrical complexity.
3. Nose model reconstructed from MRI scans.
4. Ferromagnetic nanoparticles suspending in the nasal cavity to form the Ferro fluids ($\varepsilon_r > 1$).

**Results**:

**2-D channel:**
1. With magnetic guidance, particles travel though L-shaped channel contact-free.
2. All deposit at the corner without magnet.

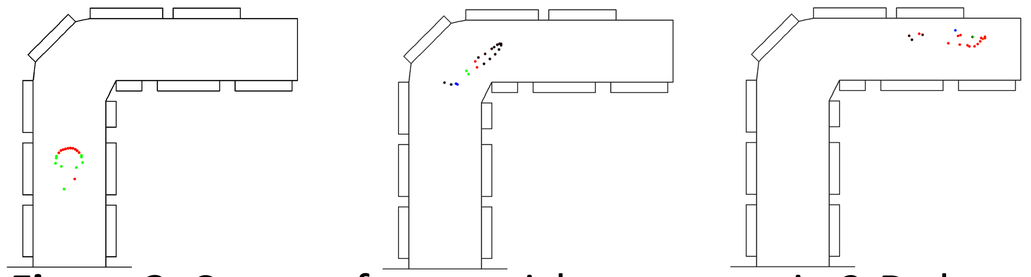


**Figure 2**. Contact-free particle transport in 2-D channel

**Image-based nose model:**

✓ Magnetic guidance improves olfactory dose

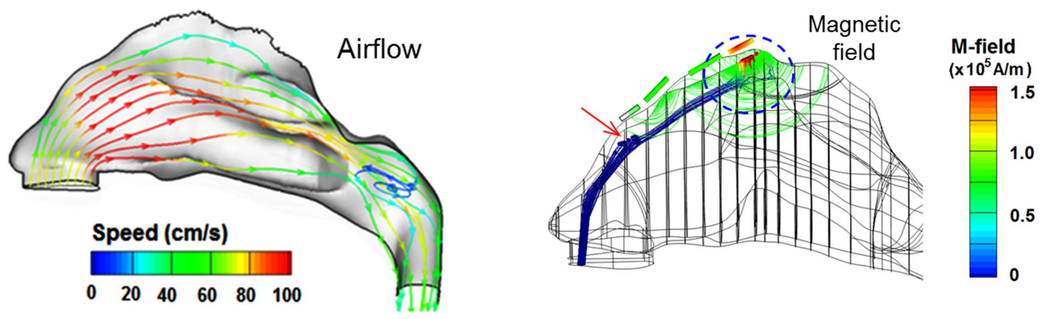



**Figure 3**. Airflow and Magnetic transport

✓ Optimization conducted on point-release

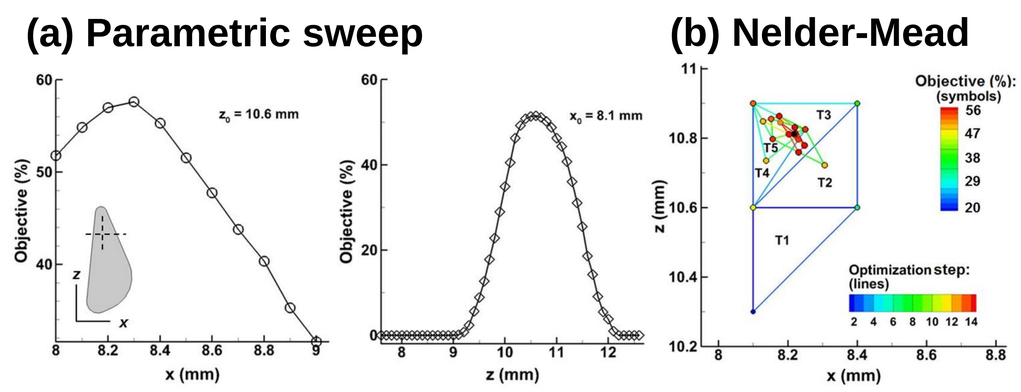
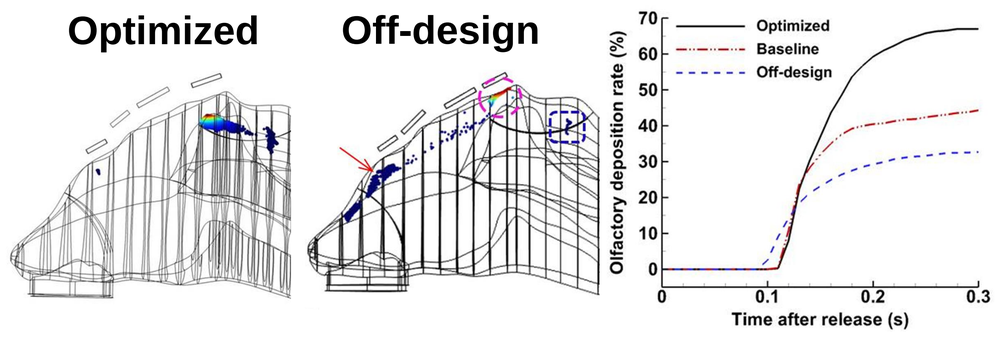



**Figure 4**. Optimization of point-release position




**Conclusions**:
1. With magnetic-guidance and point-release, improved olfactory dosing is feasible.
2. Topical delivery efficiency can be 70%.

**References**:
1. J. Xi, Z. Zhang, X. Si, Improving intranasal delivery of neurological nanomedicine to the olfactory region using magnetophoretic guidance of microsphere carriers, Int. J. Nanomedicine, 10, 1211-1222, (2015).