Modified DBSCAN Algorithm on Oculomotor Fixation Identification

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Motivation: While dispersion based fixation identification algorithms can hardly deal smooth pursuit, velocity based ones are too noisy.

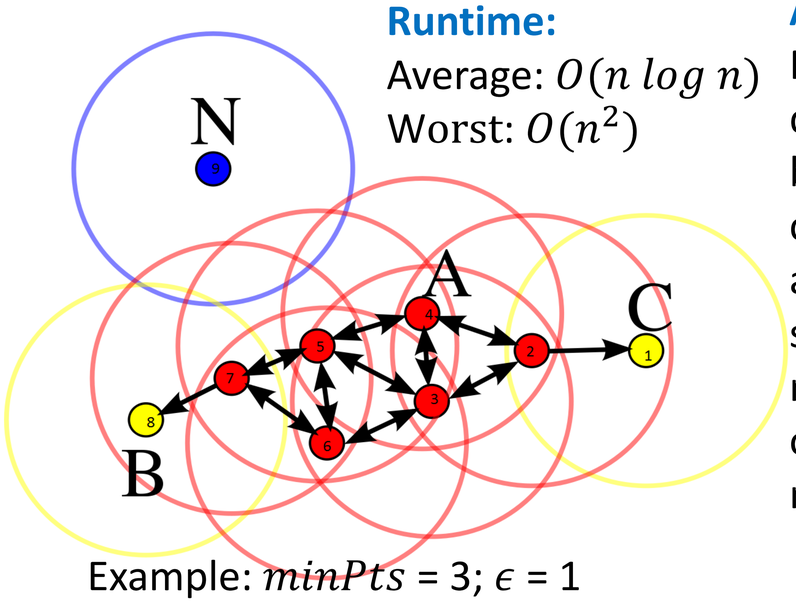
Definition

Point p is a **core point** if:

1. at least $minPts$ points are within distance ϵ to point p; and
2. these points form a consecutive subsequence $p_0, p_1, \dots, p_k$ of the dataset, where p_i and p_{i+1} are adjacent in time.
3. Those points are called **directly reachable** from p.

A point q is **reachable** from q if there is a path $p_1 = p, p_2, \dots, p_n = q$ where each p_{i+1} is directly reachable from p_i .

If p is a core point, then it forms a **cluster (fixation)** together with all points that are reachable from it.



Example: $minPts$ = 3; ϵ = 1

Runtime:
Average: $O(n\ log\ n)$
Worst: $O(n^2)$

Advantages:
Fixations are density based and can be arbitrary shaped. It's robust to outliers and noises.

Fixation Data	Temporal fixation overlap	SP Trajectory Coverage	# of fixations	coverage per fixation
MDBSCAN	4.1(1.5)	77%(25%)	7.5(2.6)	12.7%(6.7%)
I-DD	4(1.5)	73%(26%)	21.2(10.4)	4.2%(1.3%)
I-VT	2.2(1.9)	63%(32%)	10.9(6.8)	7.1%(2.4)

Performance

Combined Advantages of:
- Velocity based algorithm
- Dispersion based algorithm

github.com/BeibinLi/MDBSCAN

Comparison

Using GraFix, a semi-manual fixation identification tool, as ground truth, we compared the performance of I-DD, I-VT, and MDBSCAN. (Note: GraFix is based on I-VT). Linear Mix Model is applied to the comparison.
In Terms of Mean fixation time, I-VT is the closest to ground truth ($F(2487.9)=129.0$, $p< 0.001$); in terms of number of fixations per second, MDBSCAN is the closest ($F=18$, $p<0.001$); in terms of fixation coverage time, I-DD is the closest ($F=10.3$, $p<0.001$). All these algorithms have their own advantages. Further studies can research in their differences.

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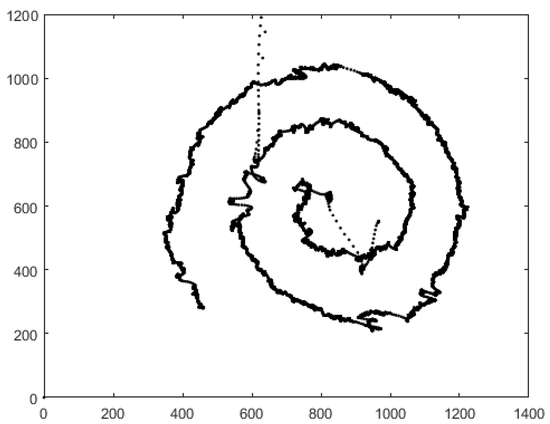
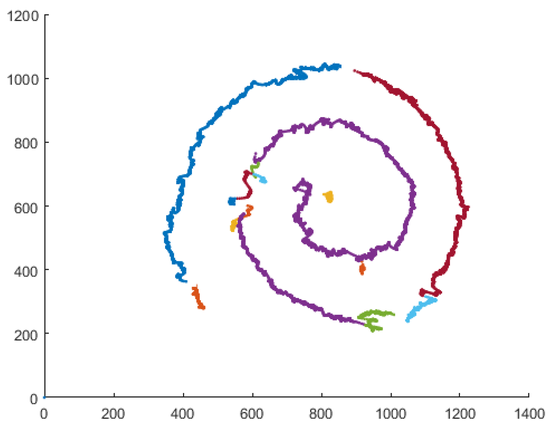
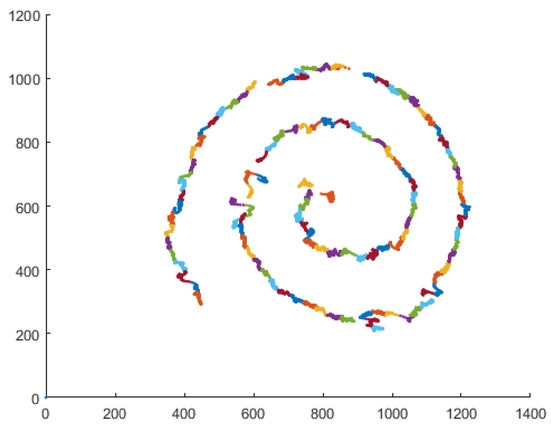
Original



MDBSCAN



I-DD



I-VT