Algorithms for the automated correction of vertical drift in eye tracking data

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The problem

C’era una volta un vecchio asino che aveva lavorato sodo per tutta la
vita. Ormai non era più capace di portare pesi e si stancava facilmente,
per questo il suo padrone aveva deciso di relegarlo in un angolo della
stalla ad aspettare la morte. L’asino però non voleva trascorrere così gli
ultimi anni della sua vita. Decise di andarsene a Brema, dove sperava di
poter vivere facendo il musicista. Si era incamminato da poco quando
incontrò un cane, magro e ansimante. “Come mai hai il fiatone?” gli
chiese. “Sono dovuto scappare in tutta fretta per salvare la pelle” gli
rispose il cane. “Il mio padrone voleva uccidermi, perché dice che sono
vecchio non gli servo più”.

Prior work

Computer science literature

Abdulin & Komogortsev (2015)

Beymer & Russell (2005)

Carl (2013)

Hyrskykari (2006)

Lima Sanches et al. (2015)

Martinez-Gomez et al. (2012)

Mishra et al. (2012)

Yamaya et al. (2017)

Behavior Research Methods

Cohen (2013)

Schroeder (in prep.)

Špakov et al. (2019)

Zhang & Hornof (2011)

Dissertations

Lohmeier (2015)

Nüssli (2011)

+ probably many other ad-hoc, in-house solutions

Two goals

1. Systematically review drift correction algorithms to provide guidance to researchers about how they work, when they should be used, and what their limitations are

2. Lay a solid foundation for future work on drift correction by constraining the problem domain, delimiting the core algorithms, and benchmarking their performance

The algorithms

- attach
- chain
- cluster
- compare
- merge
- regress
- segment
- split
- stretch
- warp

The algorithms

- attach
- chain
- regress
- warp

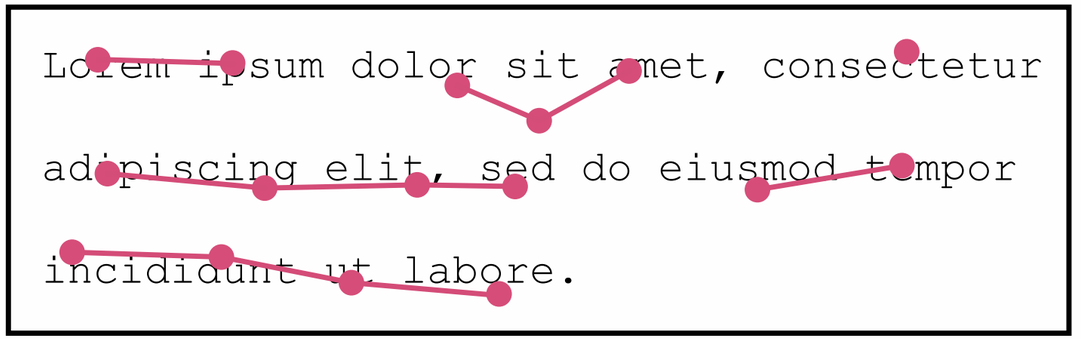
The algorithms

- `attach` *baseline algorithm*
- `chain` *absolute-positional algorithm*
- `regress` *relative-positional algorithm*
- `warp` *sequential algorithm*

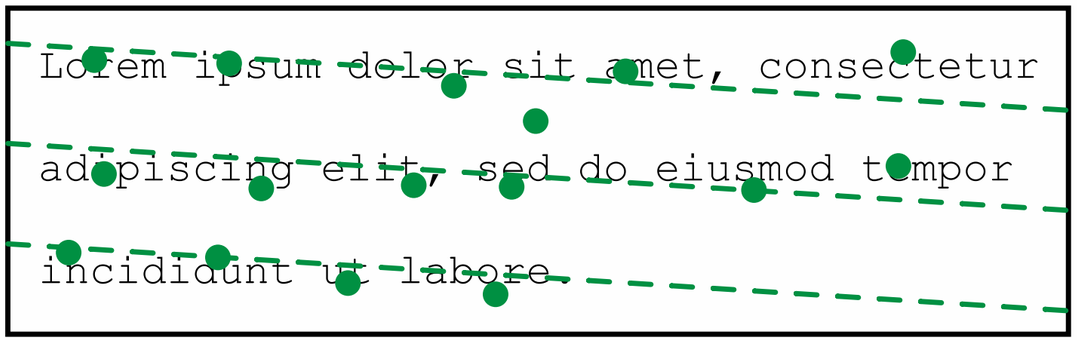
The algorithms

attach

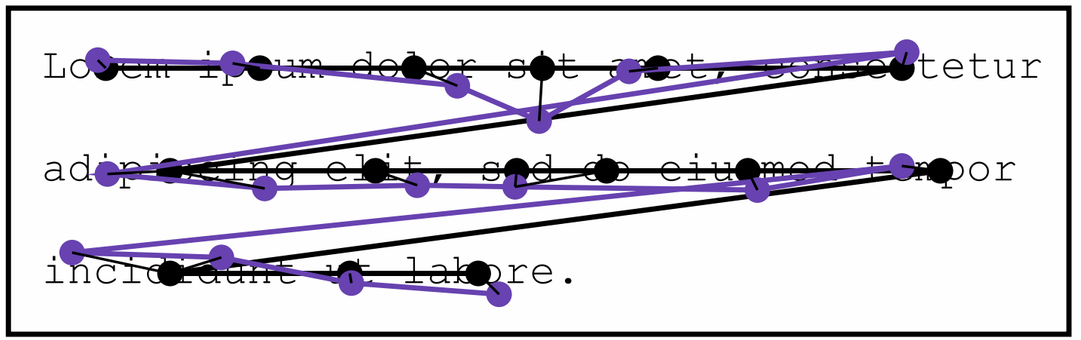
chain



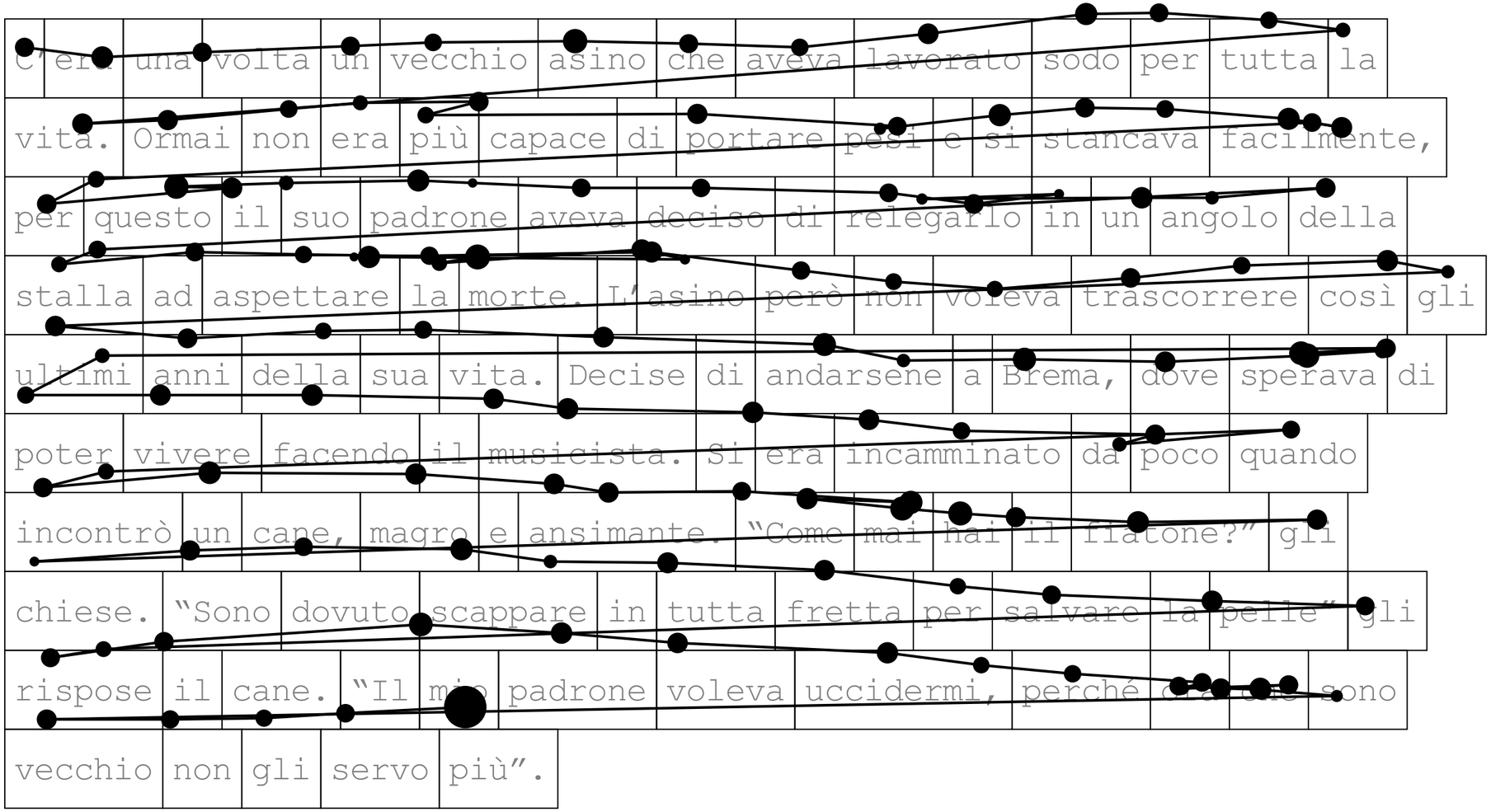
regress



warp



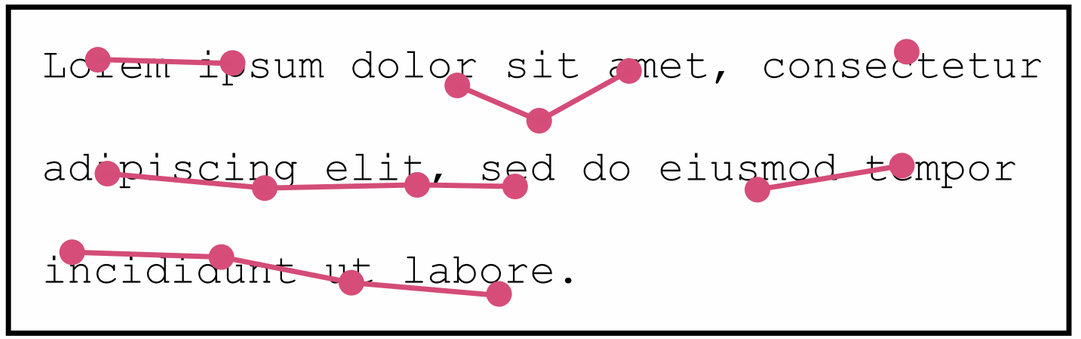
attach as a baseline



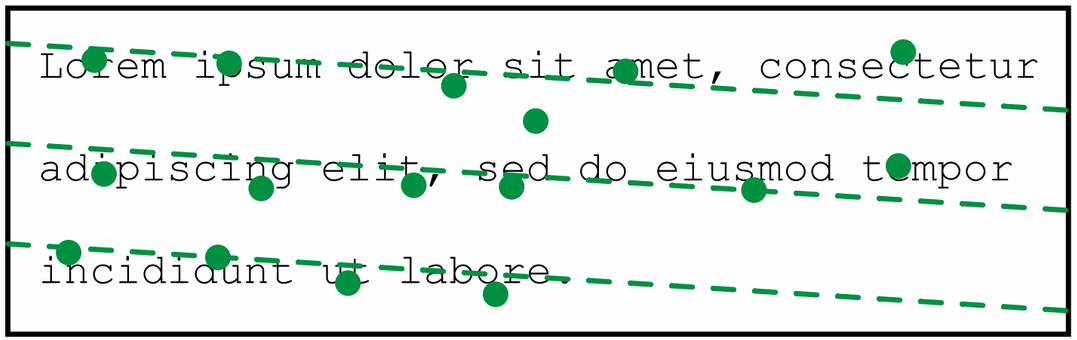
The algorithms

attach

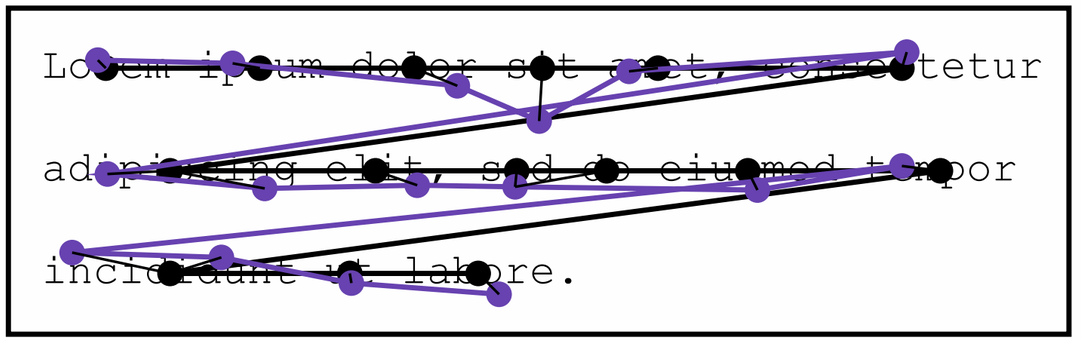
chain



regress



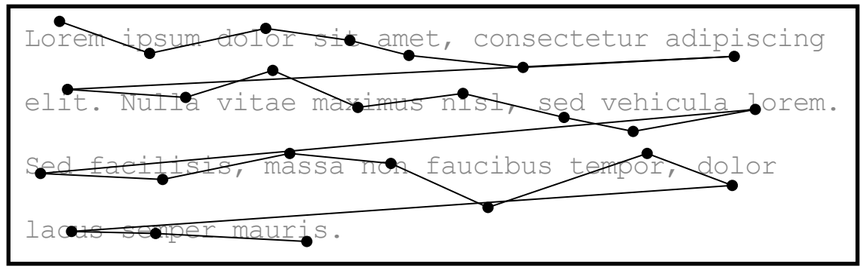
warp



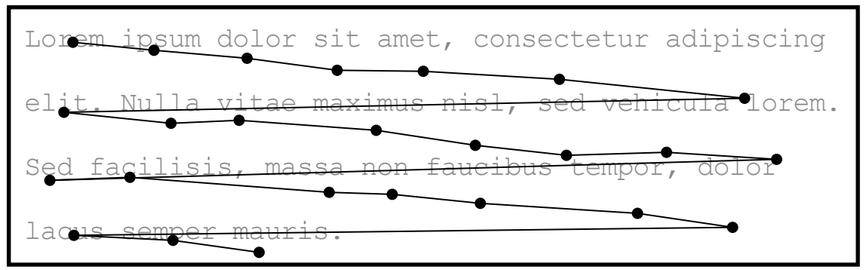
Performance on simulated data

Distortion parameters

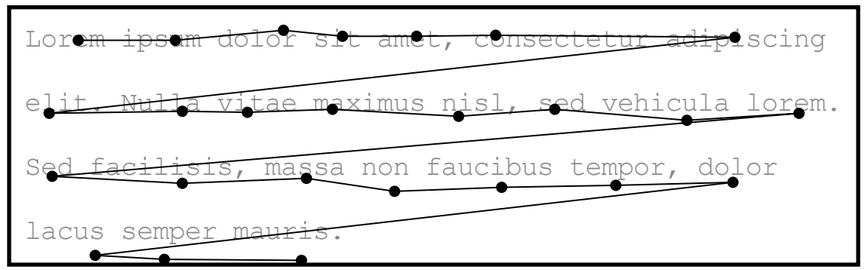
Noise



Slope



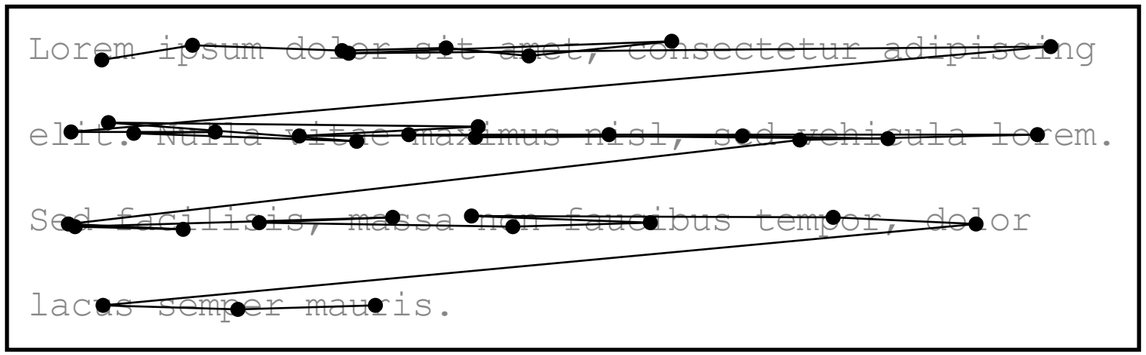
Shift



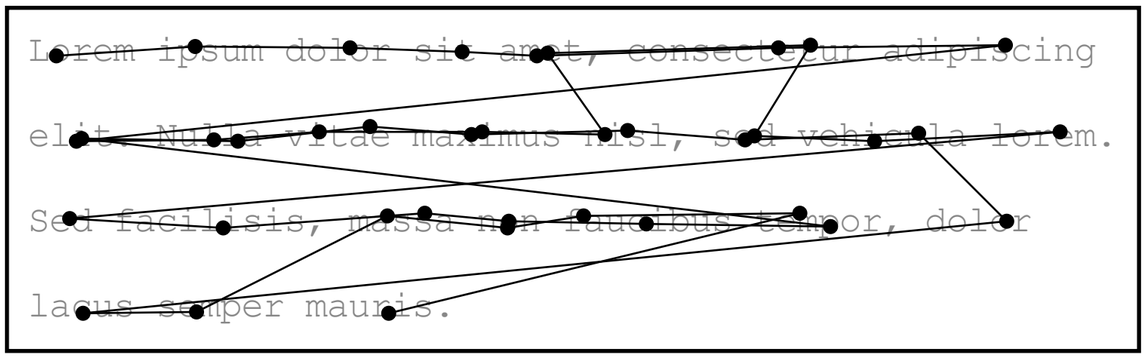
Vertical drift

Regression parameters

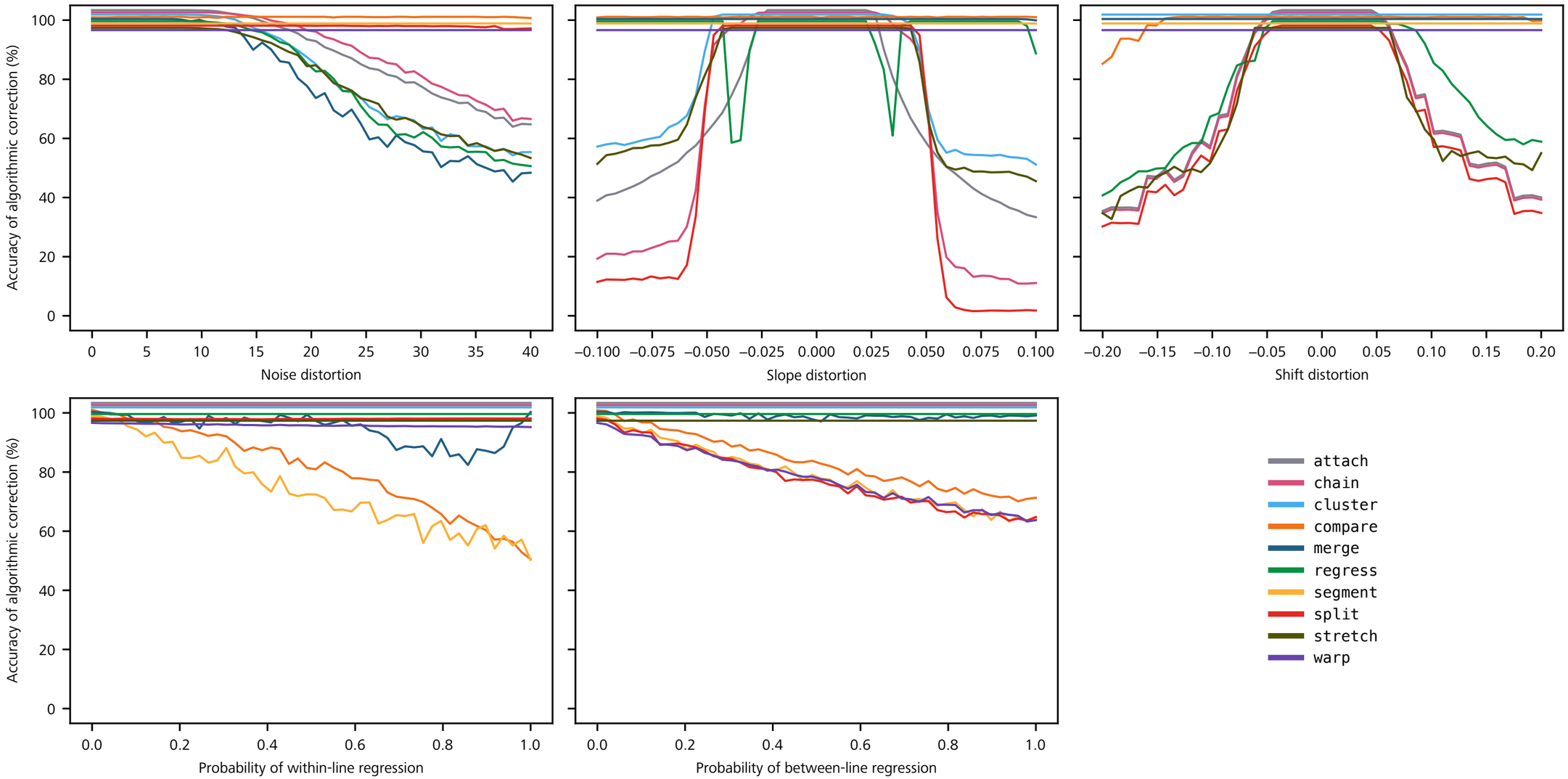
Within-line regression



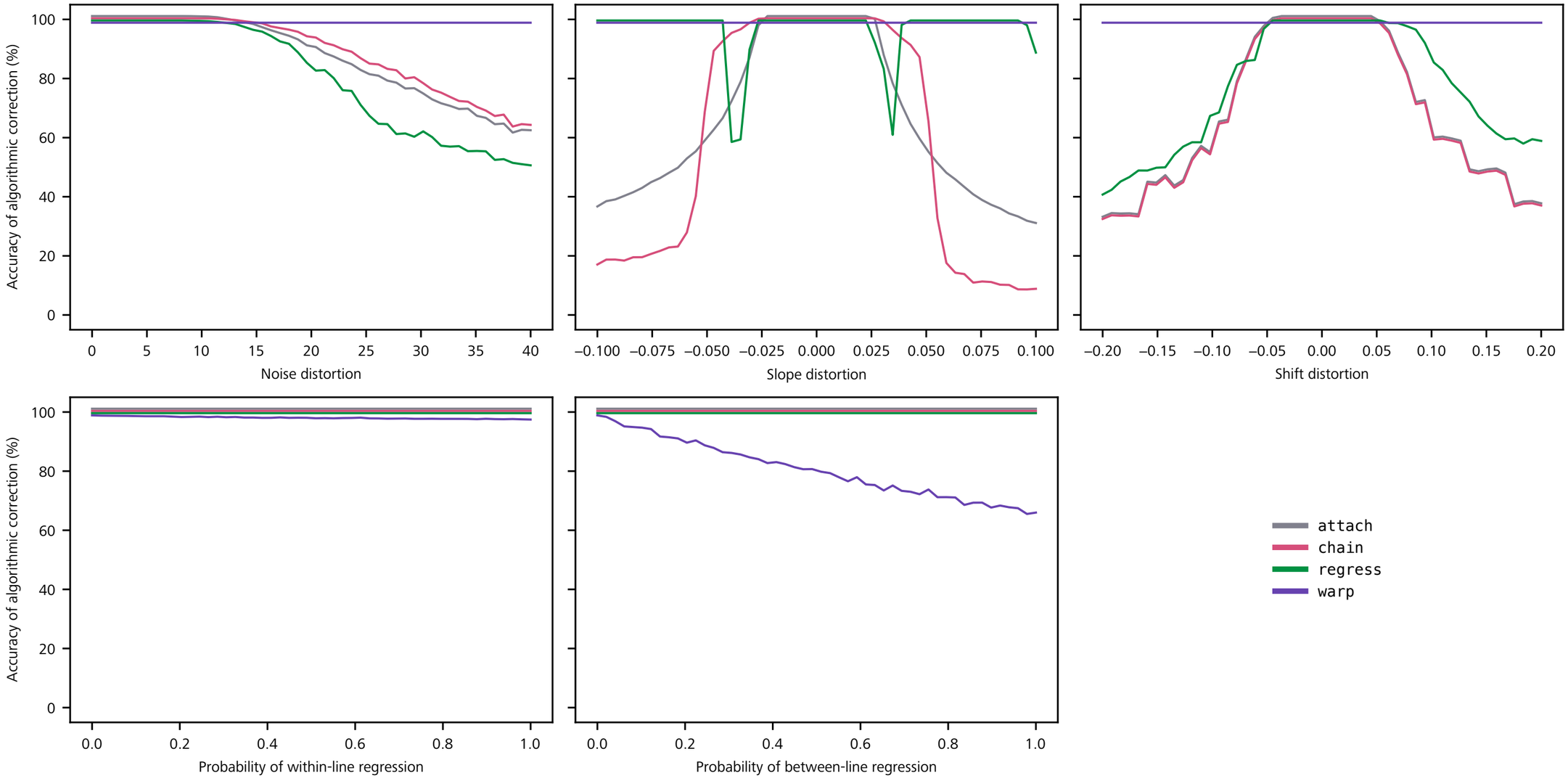
Between-line regression



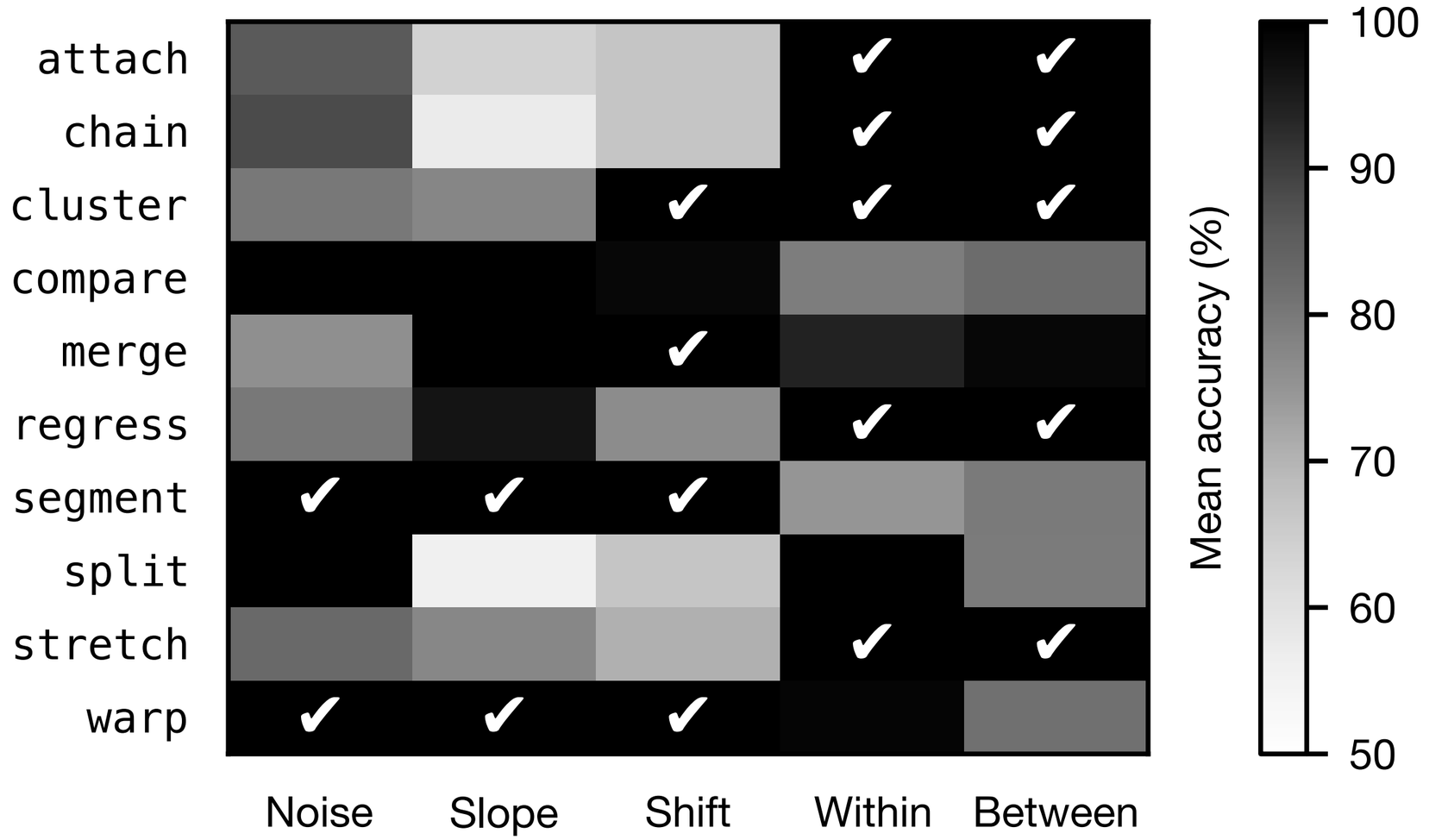
Simulation results



Simulation results

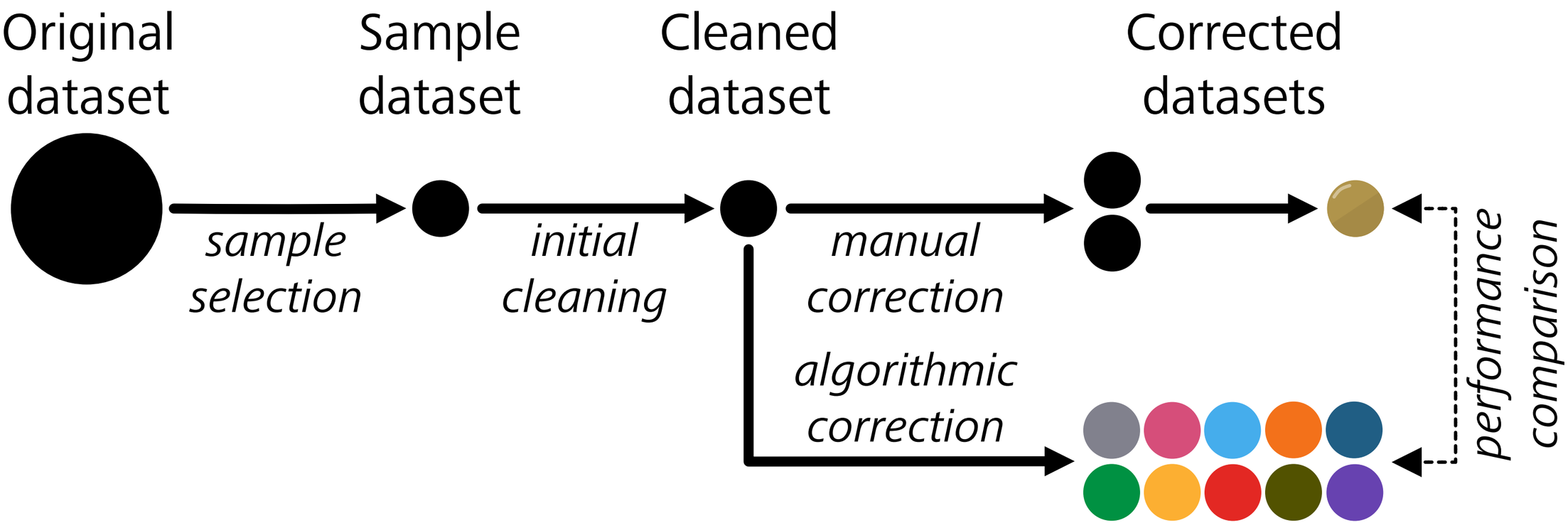


Phenomena that the algorithms are invariant to



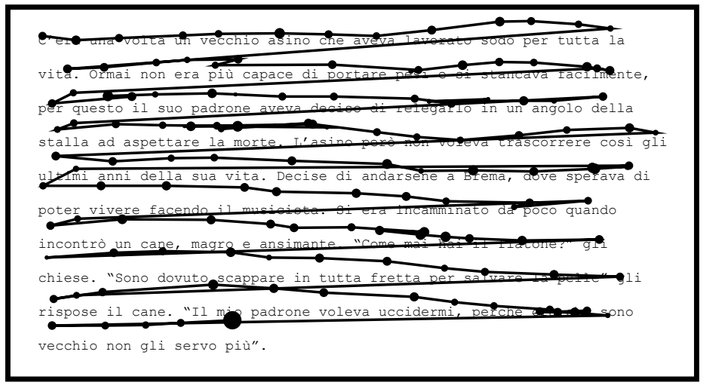
Performance on natural data

Performance on natural data

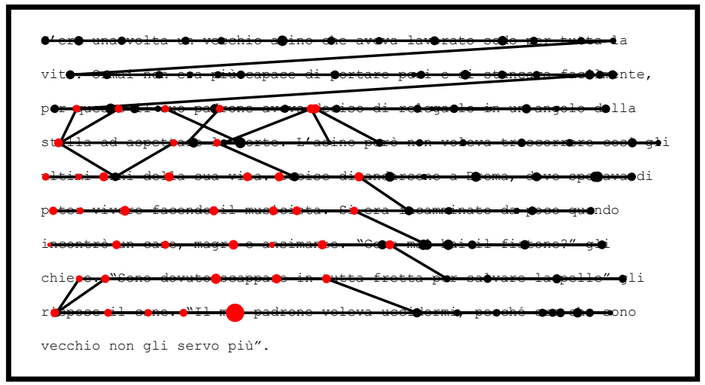


Example trial by an adult

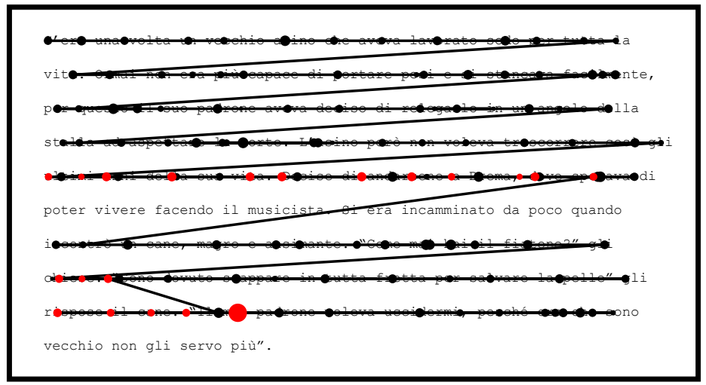
Original data



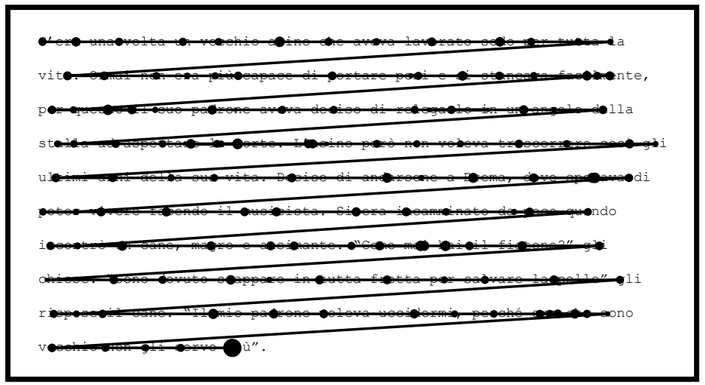
attach



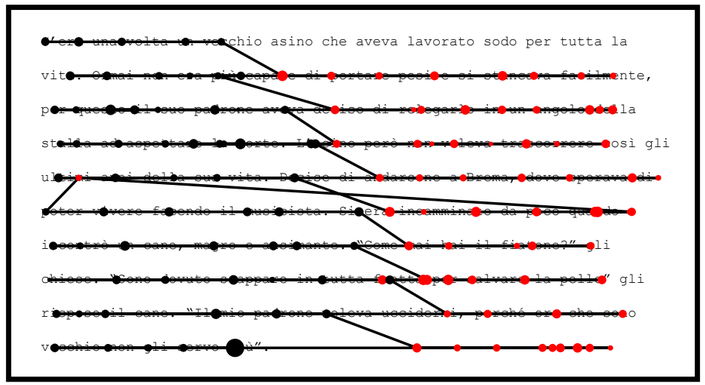
chain



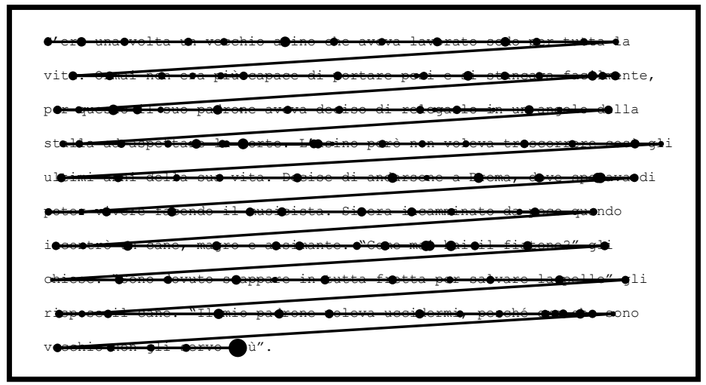
Gold standard manual correction



regress

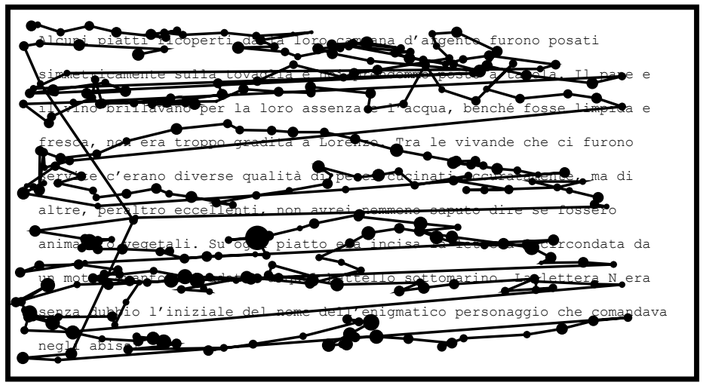


warp

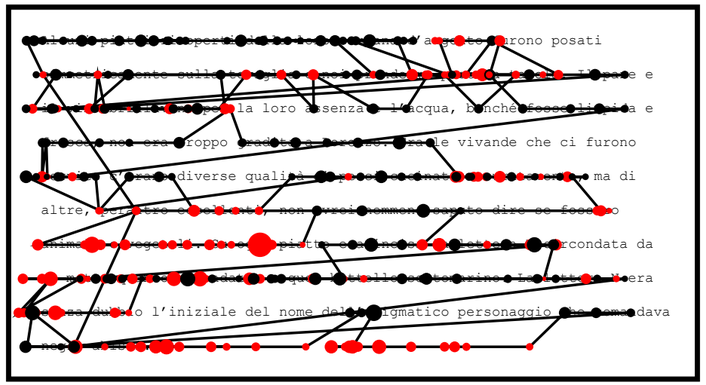


Example trial by a child

Original data



`attach`



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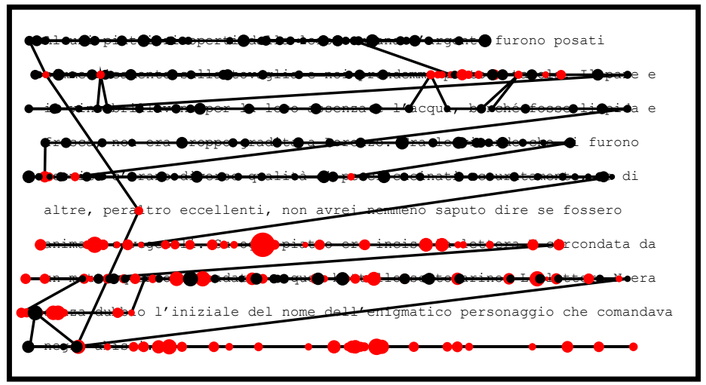
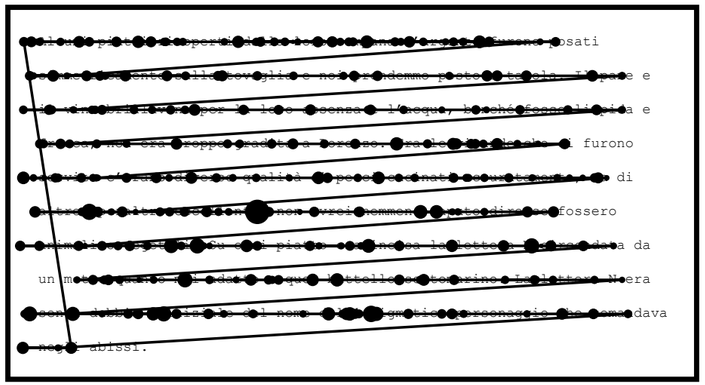
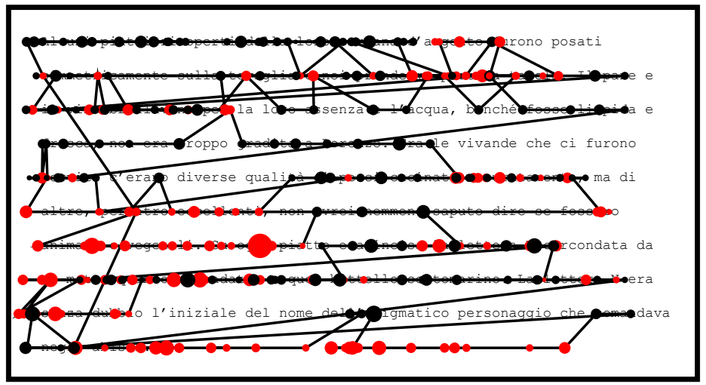


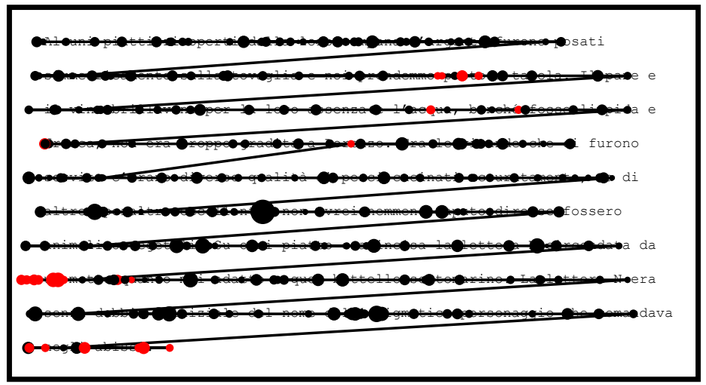
Gold standard manual correction



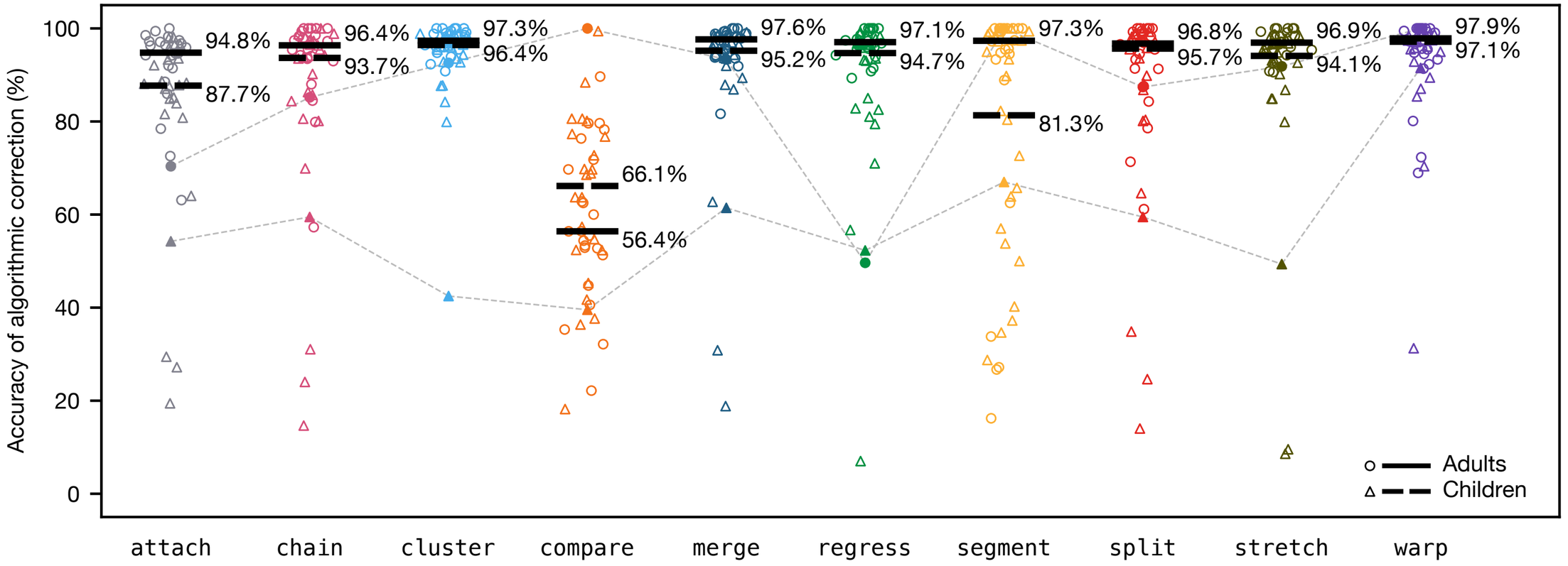
`regress`



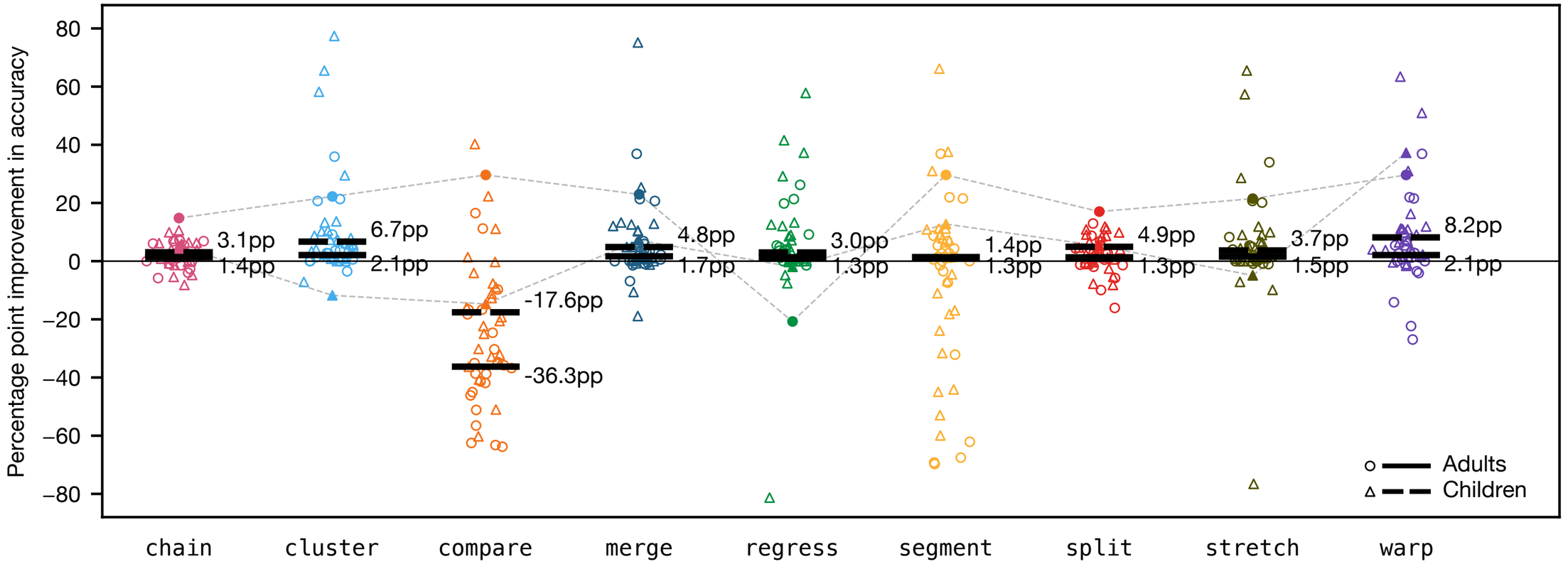
`warp`

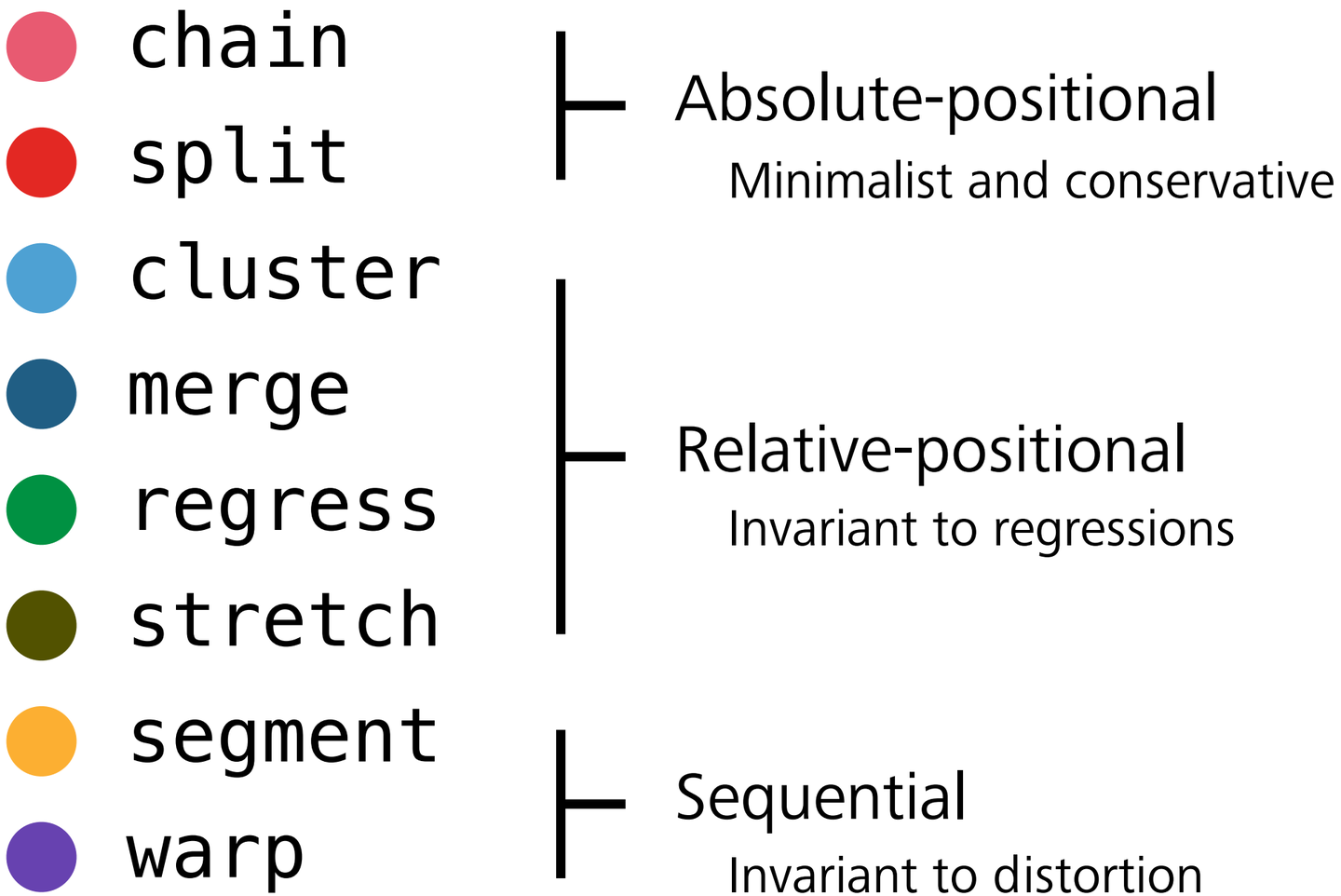


Accuracy against the gold standard



Improvement over no drift correction




chain
split
cluster
merge
regress
stretch
segment
warp
Absolute-positional
Minimalist and conservative
Relative-positional
Invariant to regressions
Sequential
Invariant to distortion

Conclusions

1. No silver bullet – some work will still be required to clean multiline reading data
2. We have provided a systematic comparison of the major algorithms, which should give researchers more confidence in using these methods
3. We have laid a solid foundation for future work in this area by unifying a disparate literature under a single framework

Get the preprint here:

doi.org/fdfj

eyekit

https://github.com/jwcarr/eyekit

popEye

https://github.com/sascha2schroeder/popEye

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