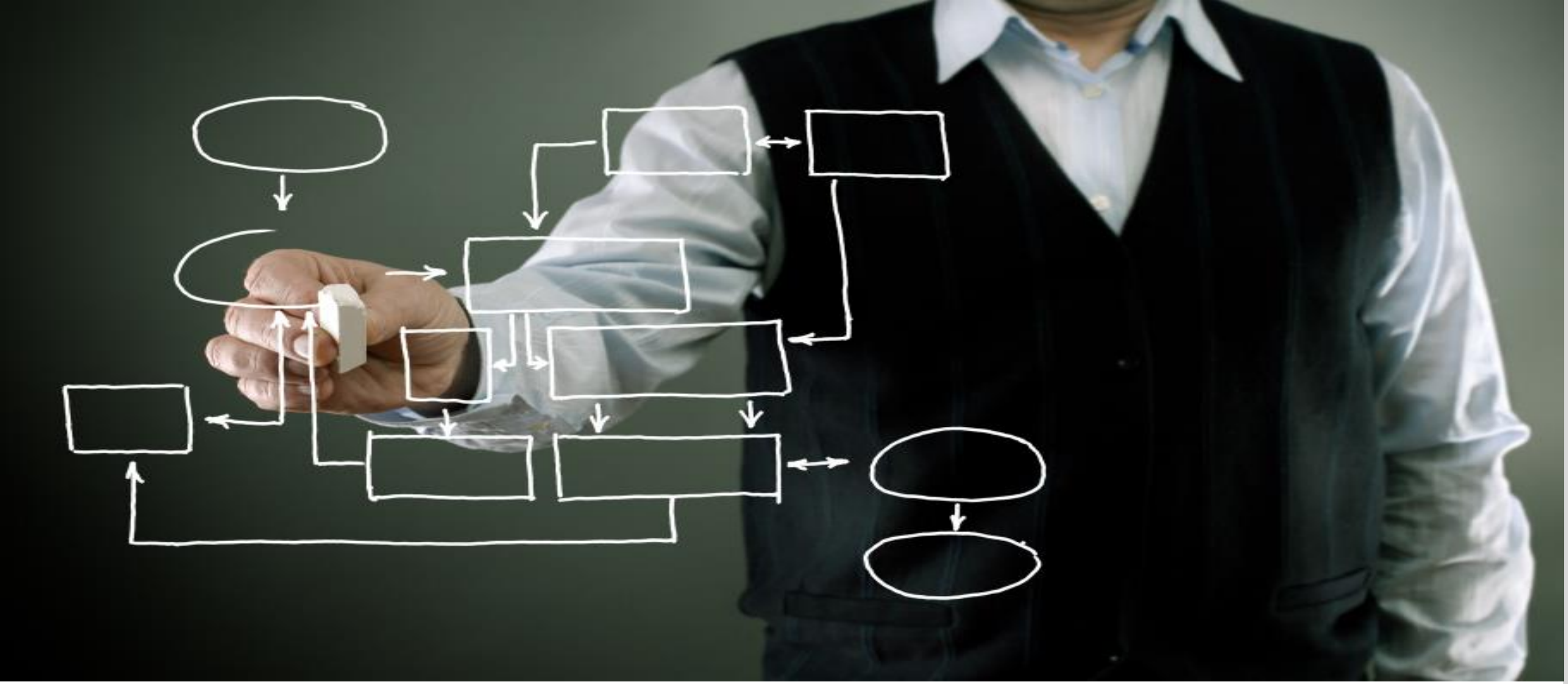


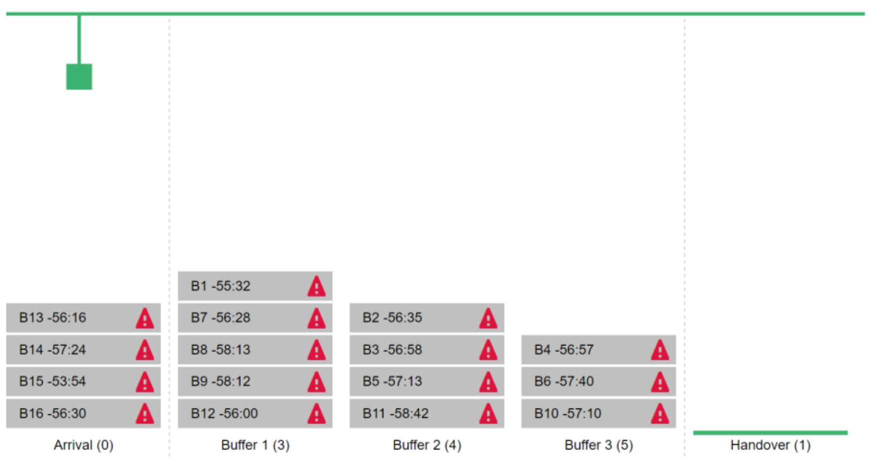
Measuring Features of Dynamic and Time-Linked Optimization Problems

Bernhard Werth, Erik Pitzer, Johannes Karder, Stefan Wagner, Michael Affenzeller

FH Oberösterreich
HeuristicLab
adaptOp
JOSEF RESSEL CENTER FOR
ADAPTIVE OPTIMIZATION IN DYNAMIC ENVIRONMENTS
Christian Doppler Forschungsgesellschaft

- Time-Linkage:
  Optimizer decisions influence problem state
- Literature sparse or highly domain specific
- DynOpt often „Tracking the Optimum“ [1]
- Practical Time-Linked DynOpt often:
  „Avoid Systemic Failure“ [2]
- Comparing Metaheuristics often difficult

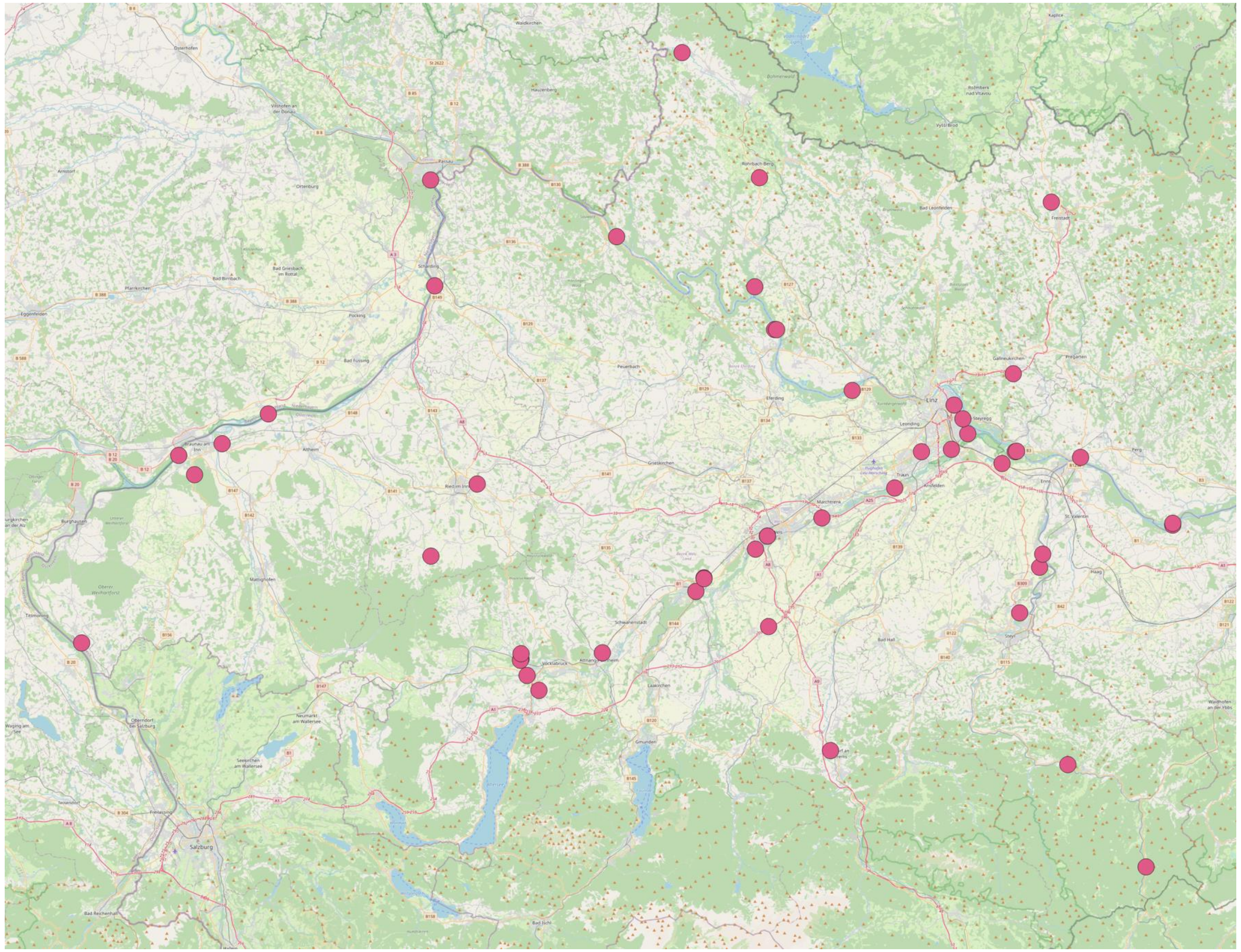
HERE BE DRAGONS



Problem: Dynamic Servicing

- Vehicle routing
- Vehicles service locations
- Fully connected distance graph
- No central depot
- Cities activate at random
  (no prior information)

- Target: cumulative active time



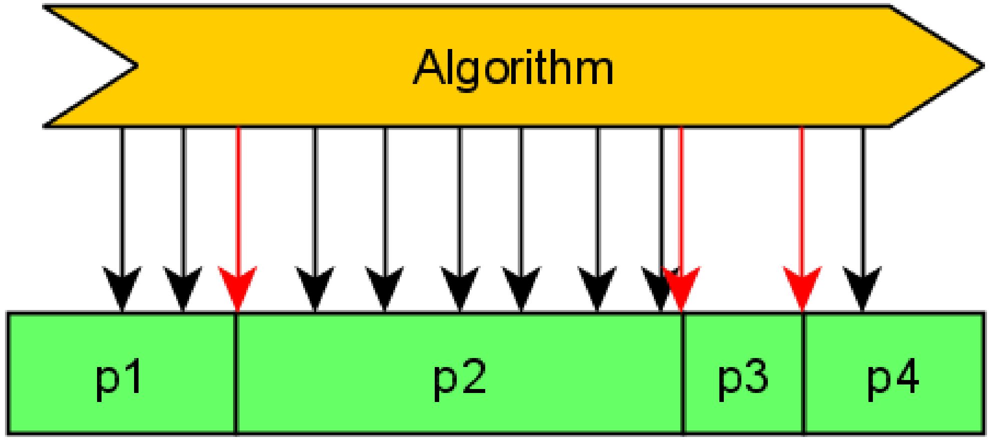
Problem Instances

- 2 Maps: Vienna and Upper Austria
- 51 Locations
- Mean-time-to-activation ~ $N(\mu_l, \sigma_l) * d$
- Drive times and service times constant
- 3 Vehicles

- Optimization target: Cumulative Active-Time (assuming no new activations)

Simulation

- Discrete event simulation
- „Decision Points“
  - Vehicle v finished servicing
  - Location l activates and at least one Vehicle idle
- No en-route-Reconsideration



- Decision:
  - Best-evaluated solution since last decision
  - Reevaluated last elite
- Stochastic and hidden Information
- Time-Linkage: Algorithm influences future problem states
  - Active/Inactive Locations
  - Vehicle positions
- Evaluation Budget proportional to time passed

Encoding

- Solution: (1,2,4,#,3,6,5,#,#) (Permutation)
- Vehicle positions (5, 6, 5)
  - V1 drives to 2, then idles
  - V2 drives to 5, then 3, then idles
  - V3 idles (although it is on an active city)
- Encoding length does not change
- Any solution always feasible

Domain-Measures

Trivial
- Active sites

Distances:
- Mean distance between active sites
- Mean distance between vehicles
- Mean distance to nearest vehicle
- Nearest neighbor disparity

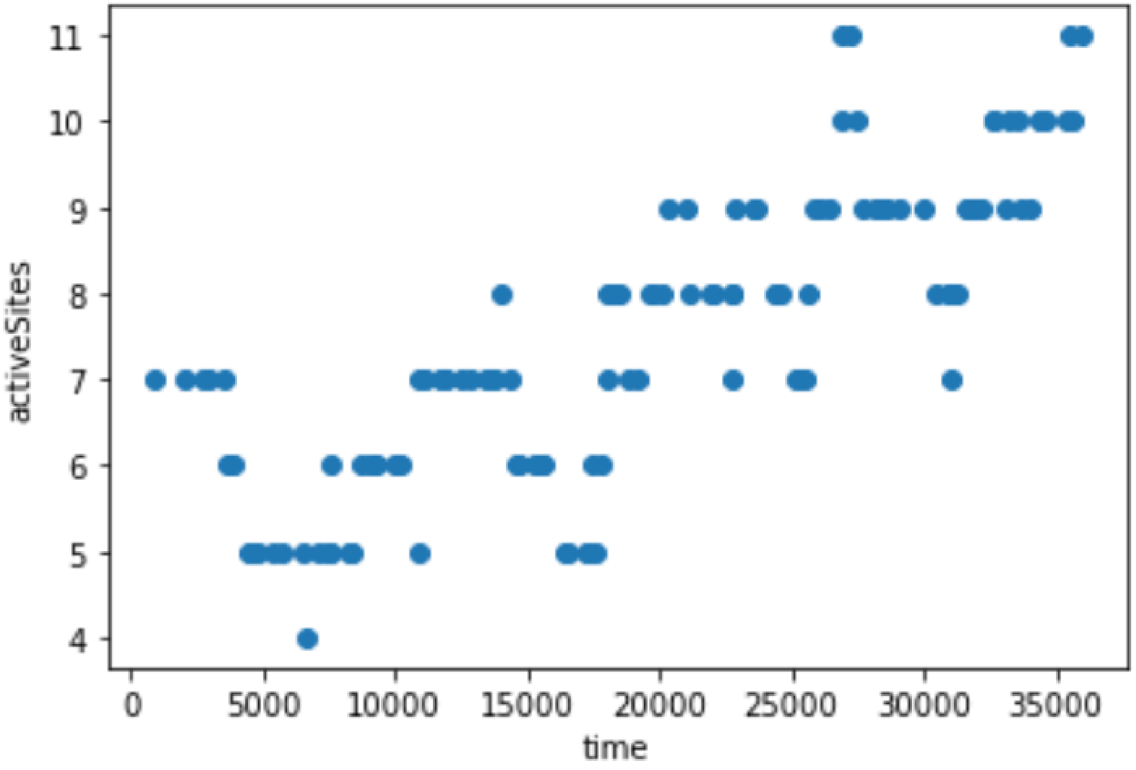
Clustering
- Inter cluster distance
- Intra cluster distance

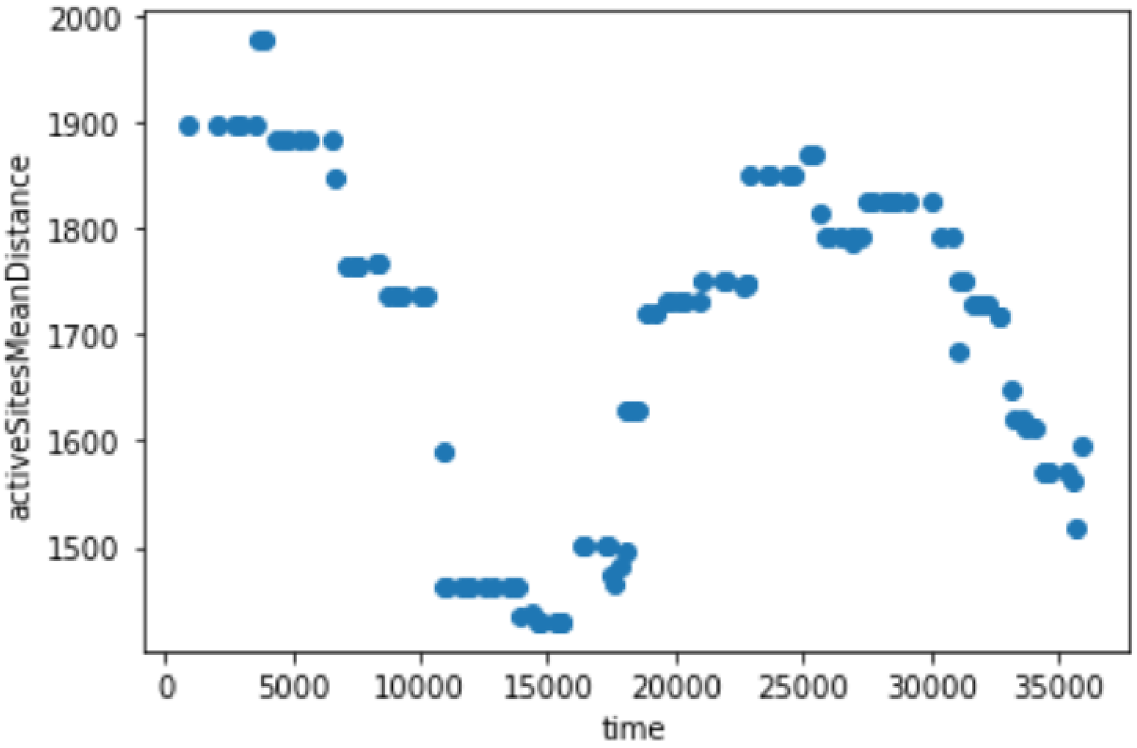
Dynamic
- Activations
- Deactivations
- Average Move Distance
- Average Path Distance

Utilization
- Travel Utilization
- Service Utilization
- Waiting Utilization

Algorithmic
- Non-Greediness

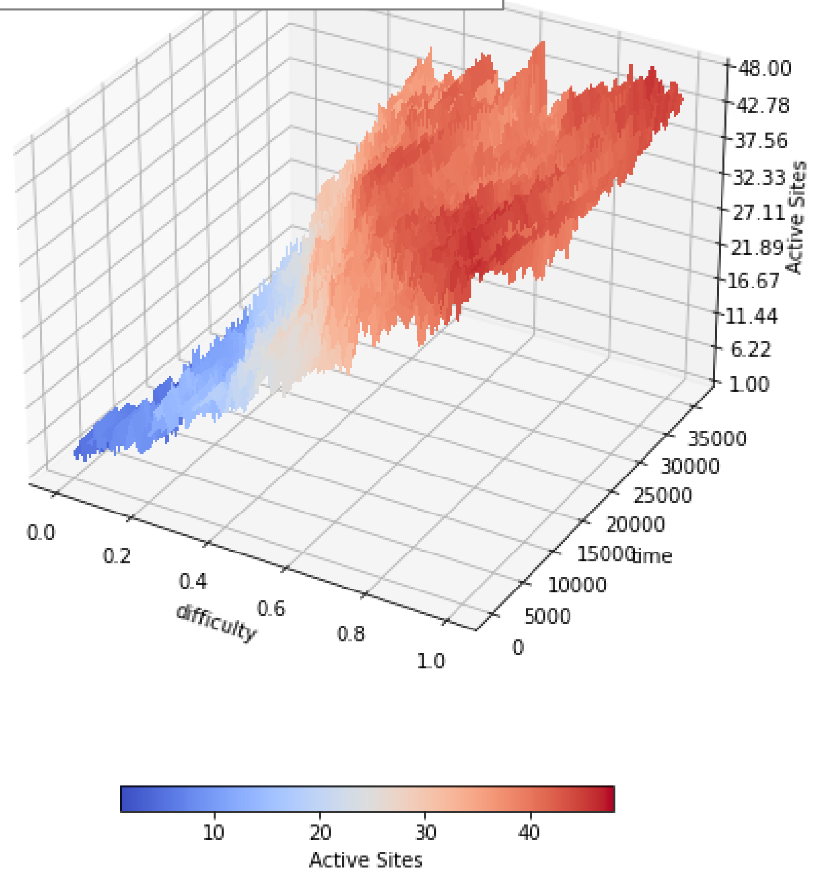
Time Line

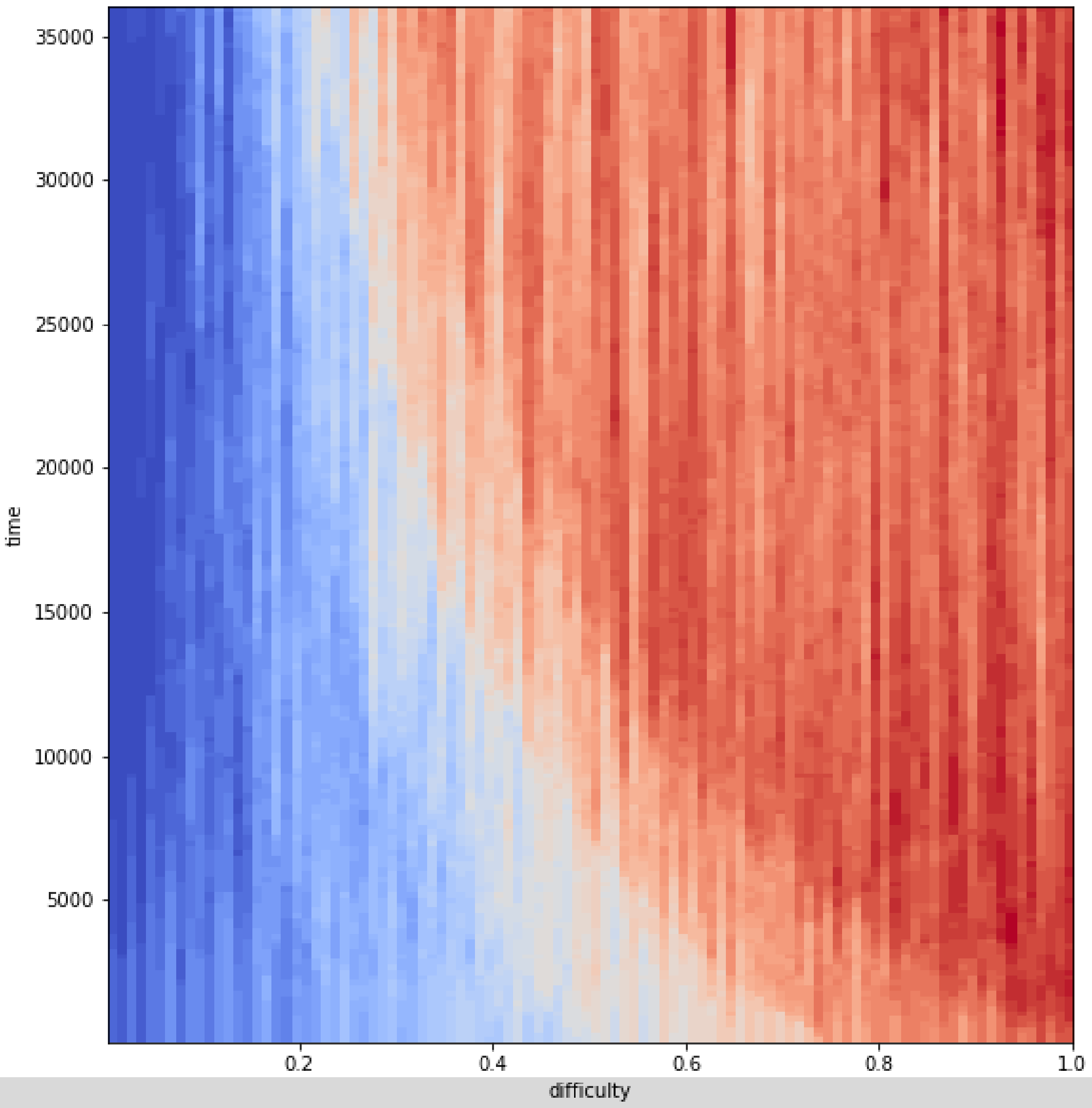

activeSites
11
10
9
8
7
6
5
4
0
5000
10000
15000
20000
25000
30000
35000
time


activeSitesMeanDistance
2000
1900
1800
1700
1600
1500
0
5000
10000
15000
20000
25000
30000
35000
time

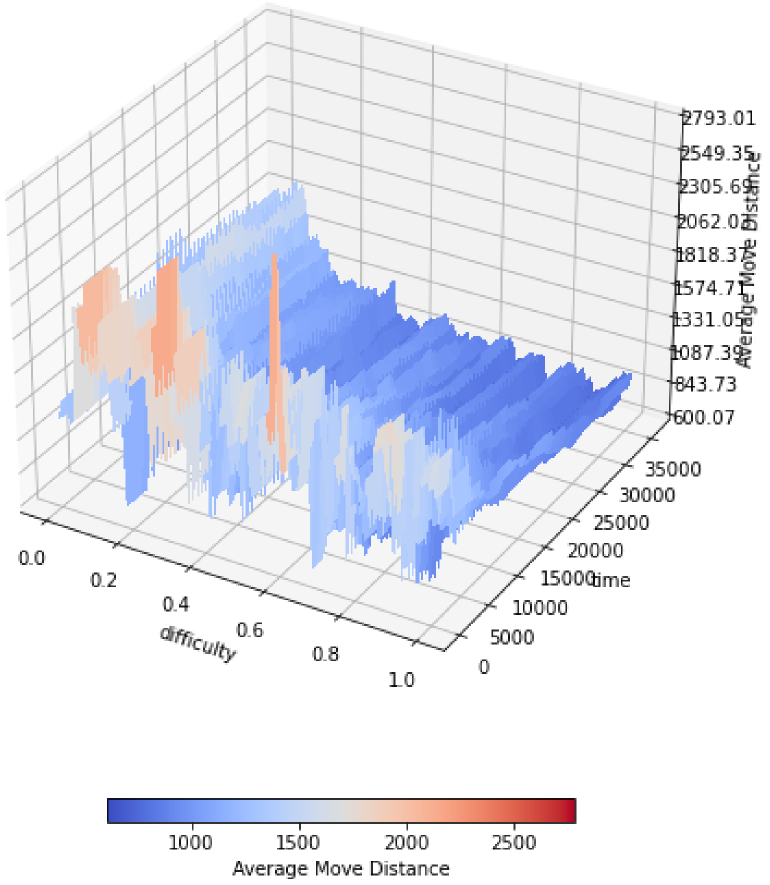
Comparing Timelines

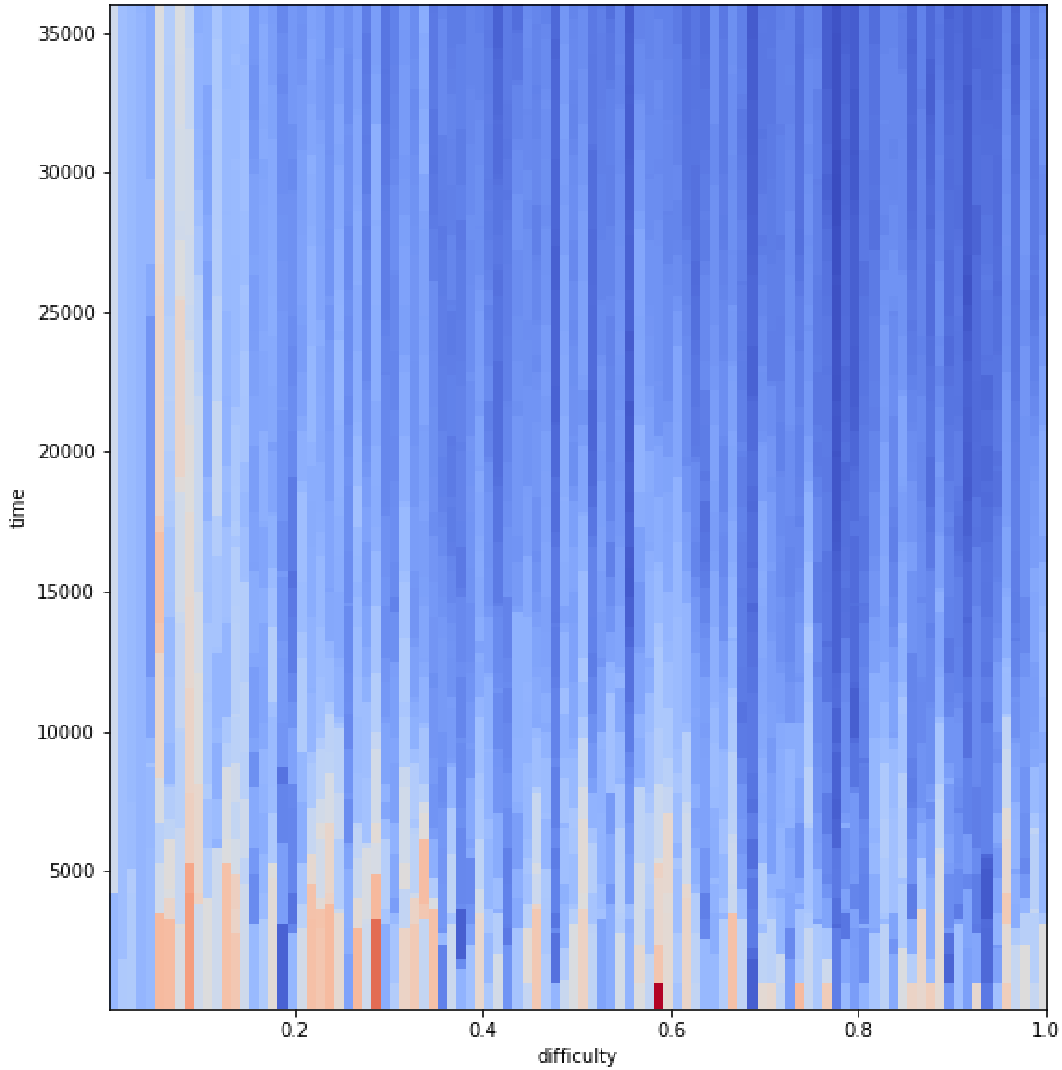
$$difficulty \sim \frac{Mean\ Activation\ Time}{Vehicle\ Speed}$$



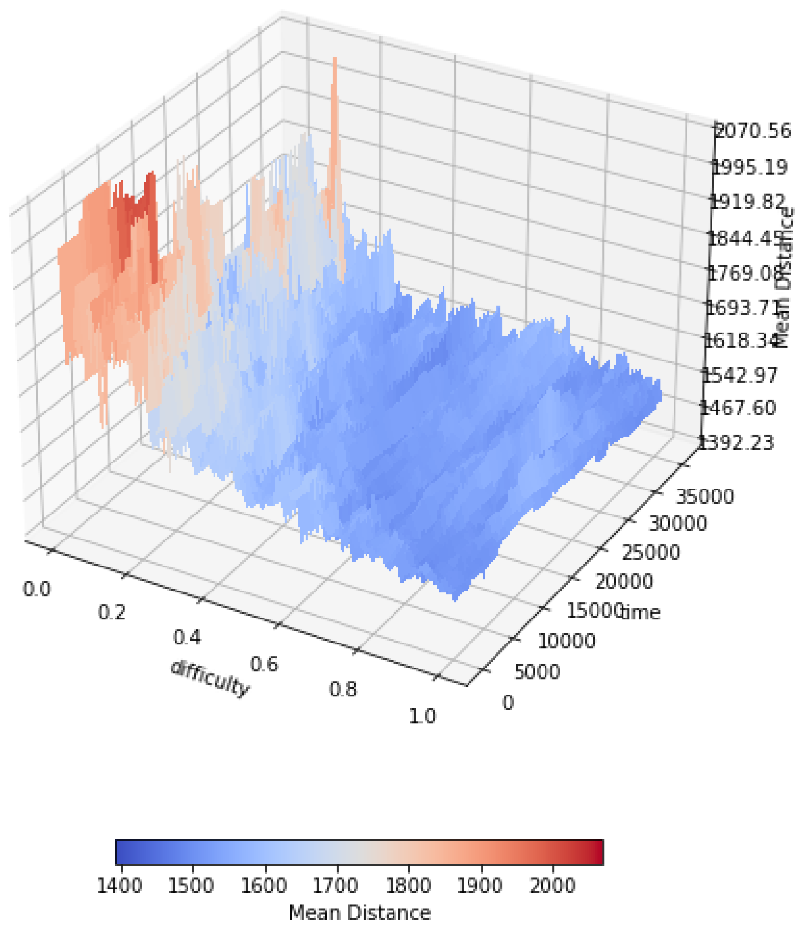


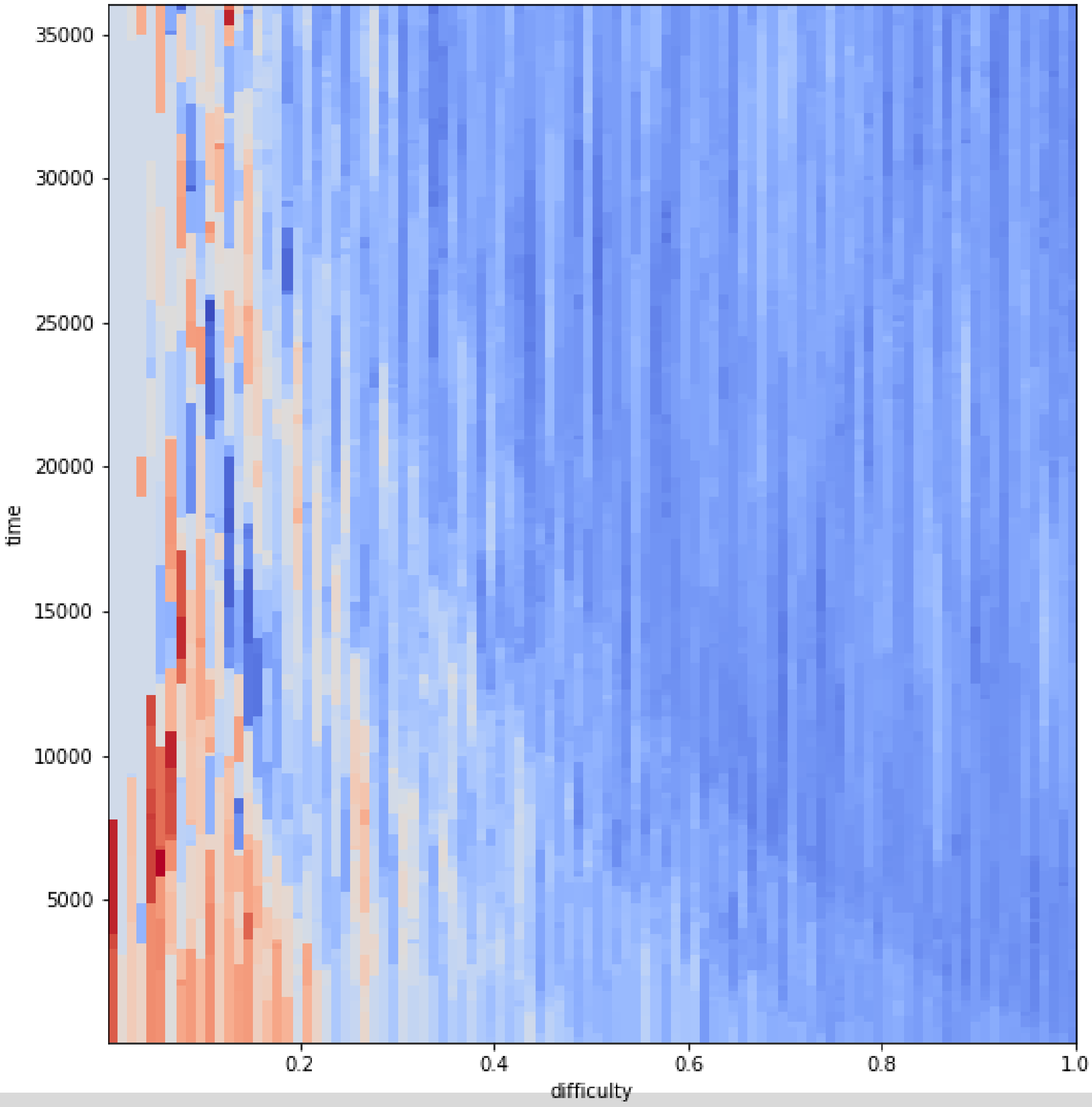
Average Move Distance





Comparing Timelines - Mean Distance



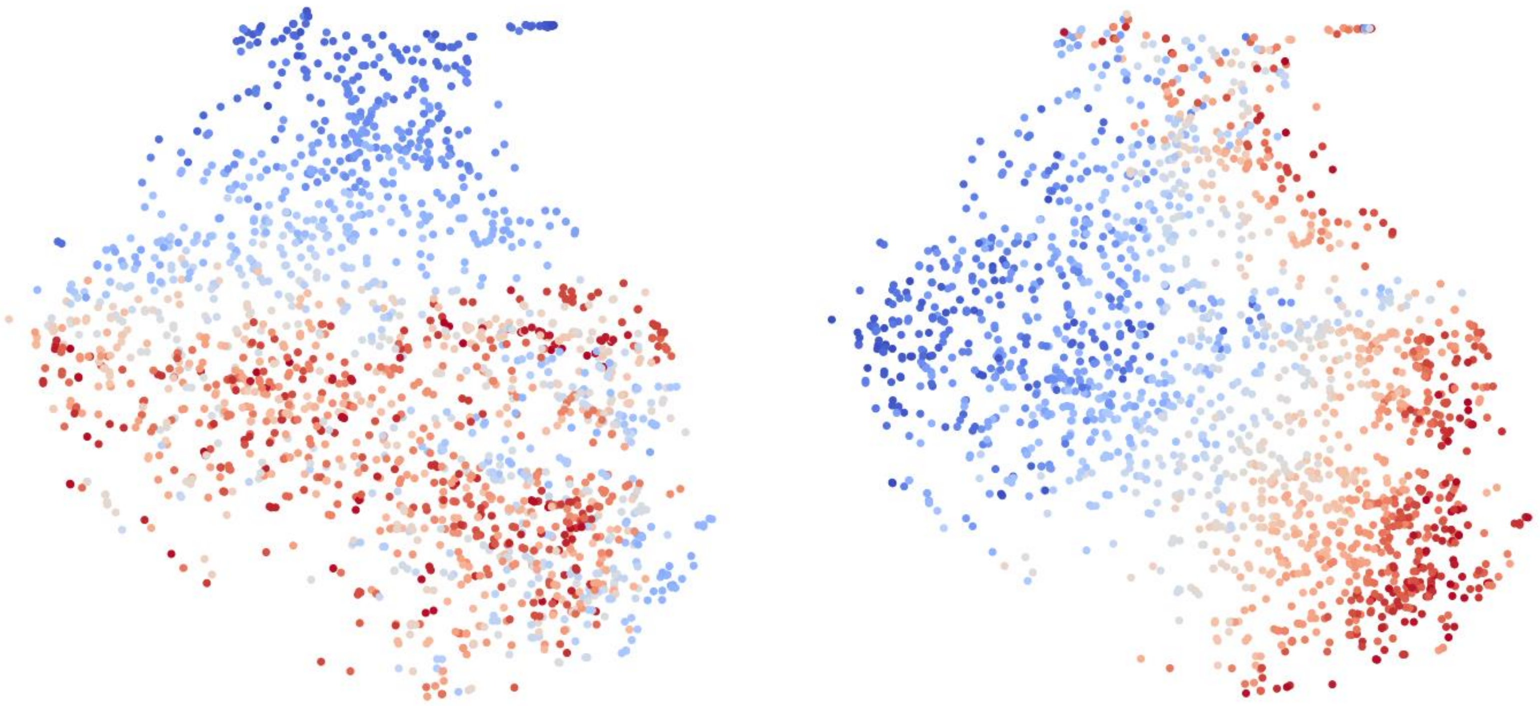


Visual Data Exploration

Use all features

- Except difficulty & time
- Normalize time-correlated features

TSNE: 2d embedding



Colored by difficulty

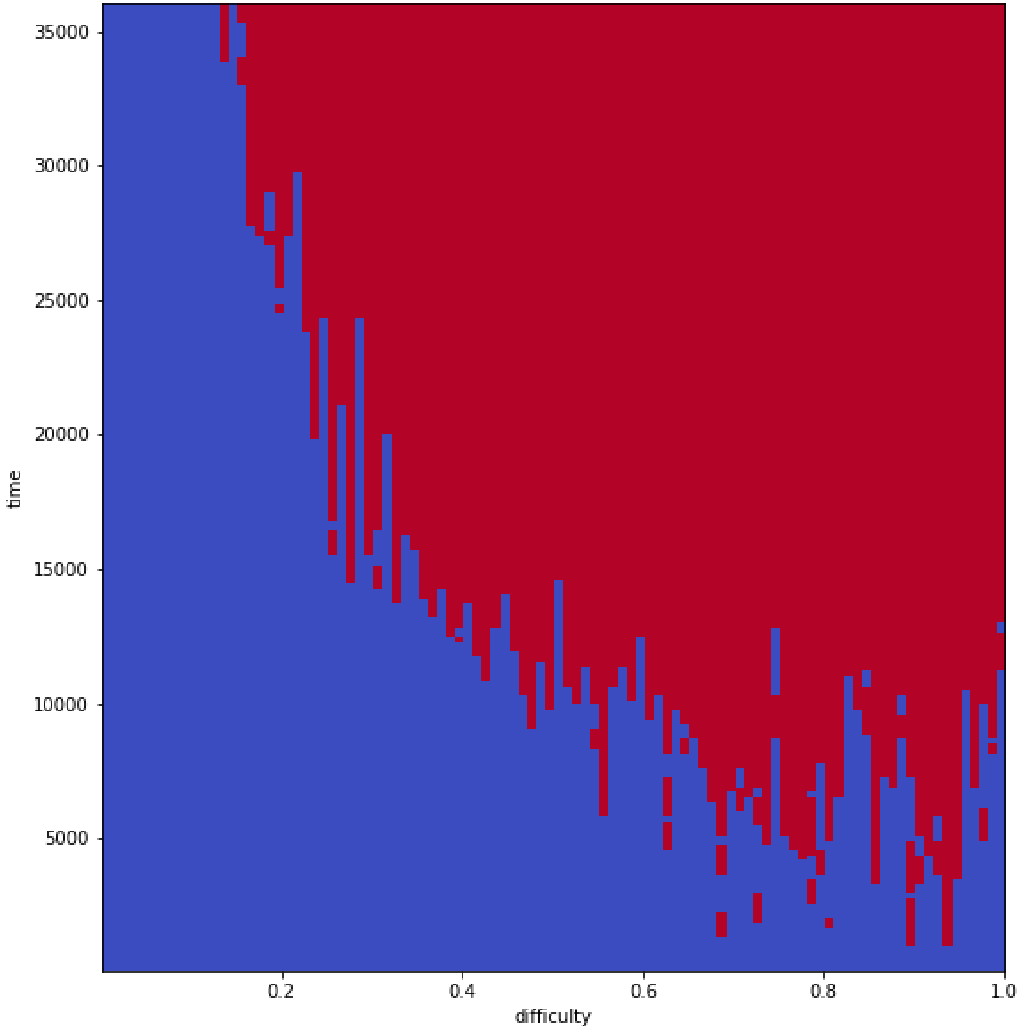
Colored by time

Clustering

- K-means (k =2)

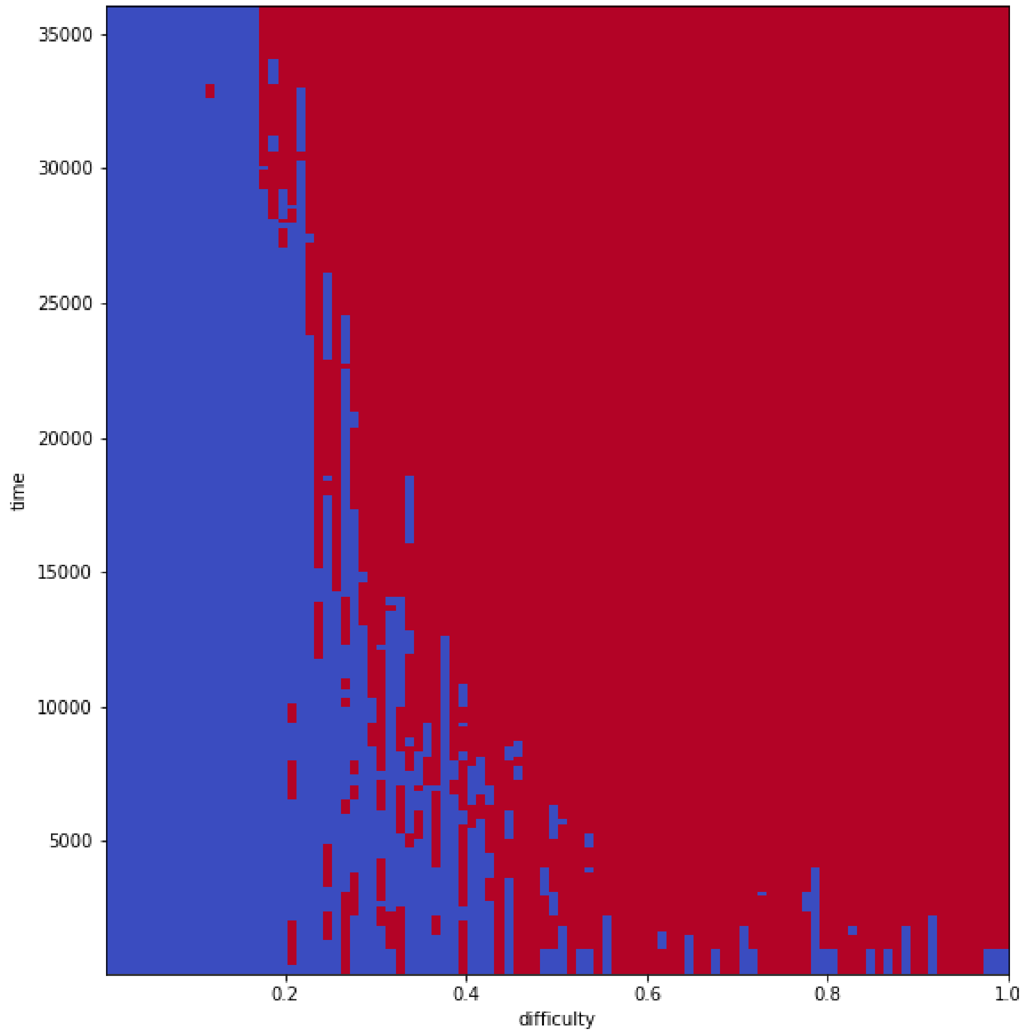
- Blue: „good“ states
- Red: „bad“ state

- The critical Border
- Time of „control loss“
- Depends on problem parameters



Critical Border for Comparing Algorithms

- **Simulated „Bad“ Algorithm**
  - 1/100 the execution budget
- **Critical border earlier & at lower difficulties**
- **„Point of no Supervision“**
  - Difficulty-component of the Border function for time = ∞
  - Appears to be similar



Conclusion

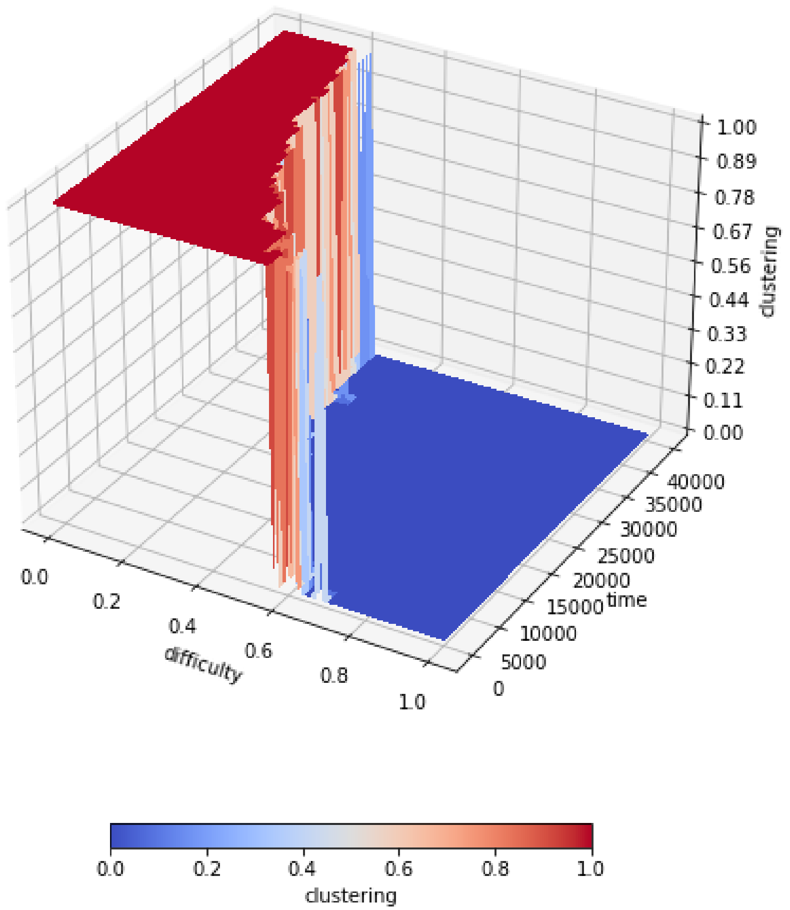
Analysis of time-linked problems

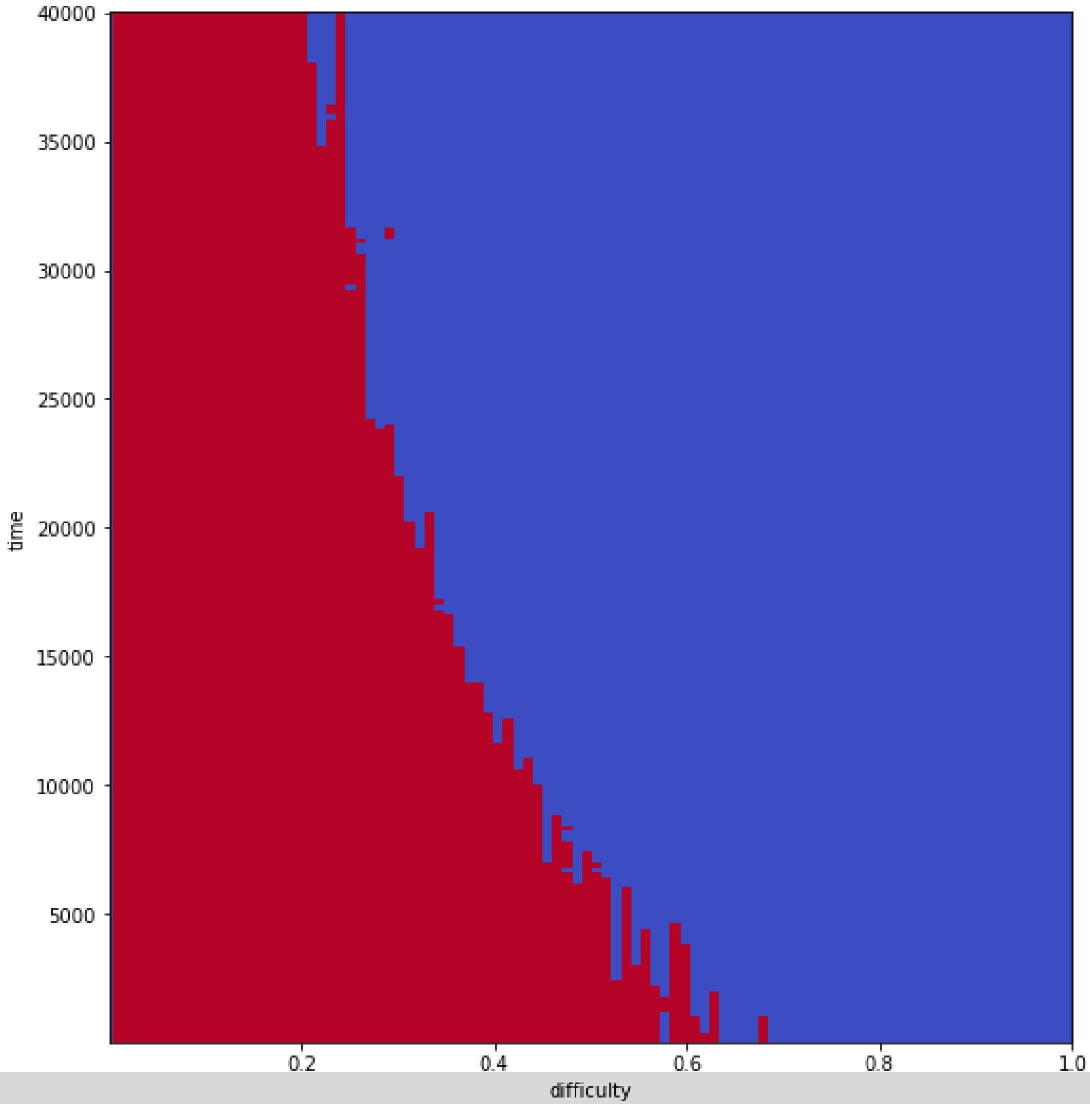
- Gain insight
- Compare algorithms
- Estimate optimizer/problem limits
- (Predict) state deterioration

Domain specific features

- Cheap to calculate
- Mixed usefulness

Sneak Peak: Critical Border (FLA)





- [1] Nguyen, T. T., Yang, S., & Branke, J. (2012). Evolutionary dynamic optimization: A survey of the state of the art. *Swarm and Evolutionary Computation*, *6*, 1-24.
- [2] Werth, B., Karder, J., Beham, A., & Wagner, S. (2021, July). Dynamic landscape analysis for open-ended stacking. In *Proceedings of the Genetic and Evolutionary Computation Conference Companion* (pp. 1700-1707).