Activity Mathematics:

Pattern Classification in Dense Sensor Fields

A brief summary of work to date

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Major Ideas

- Dimensionality Reduction
- Clustering
- Pattern Matching
- Minimum Description Length
- Anomaly Detection

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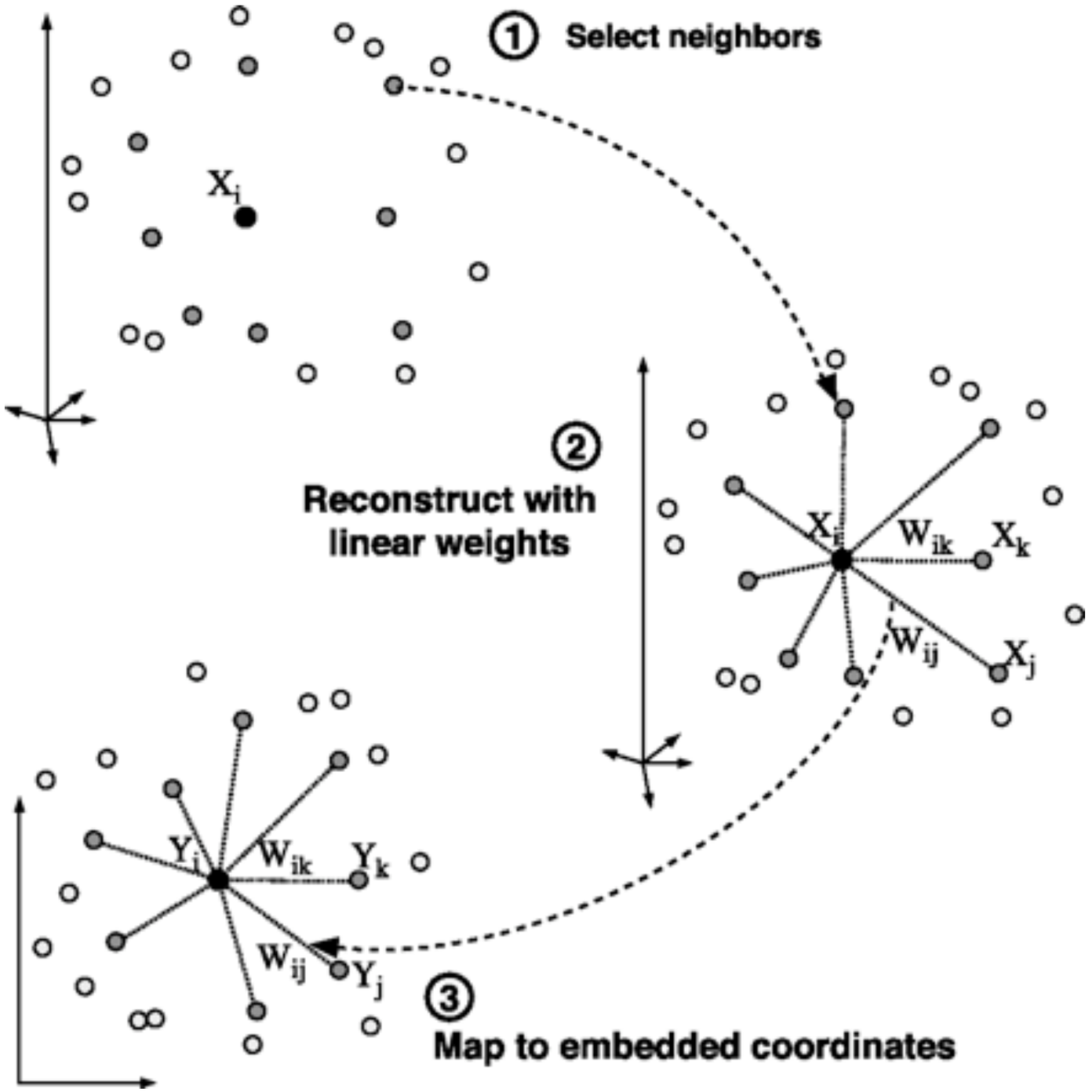
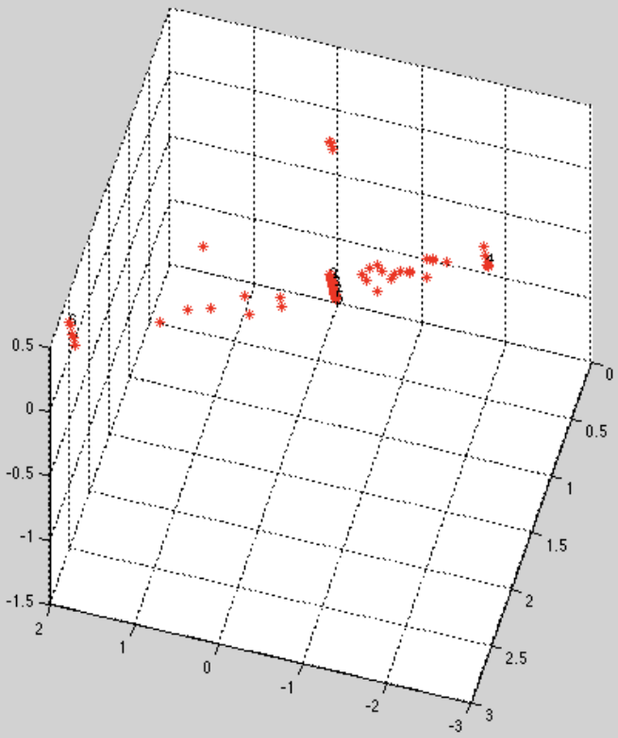
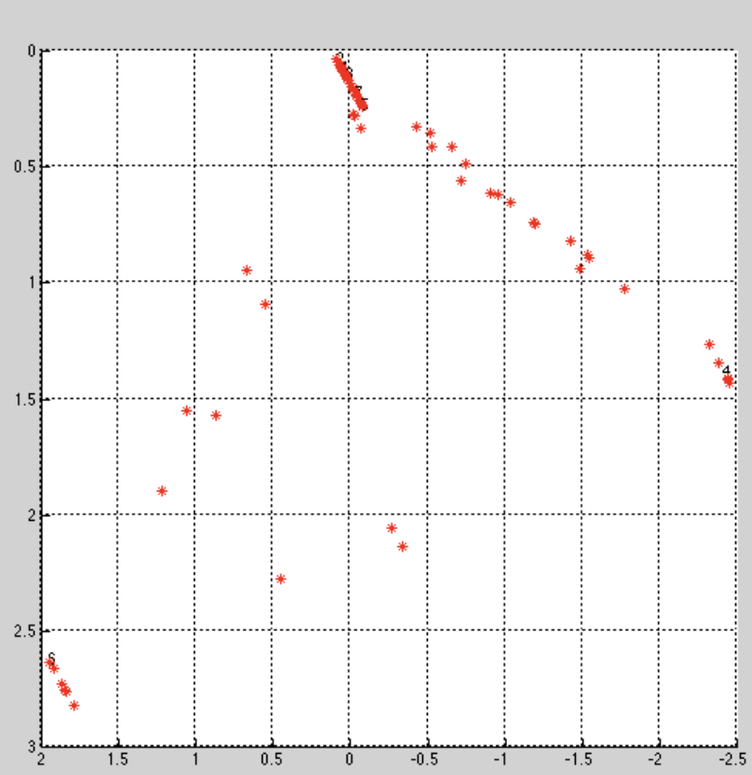
Locally Linear Embedding



LLE - Results



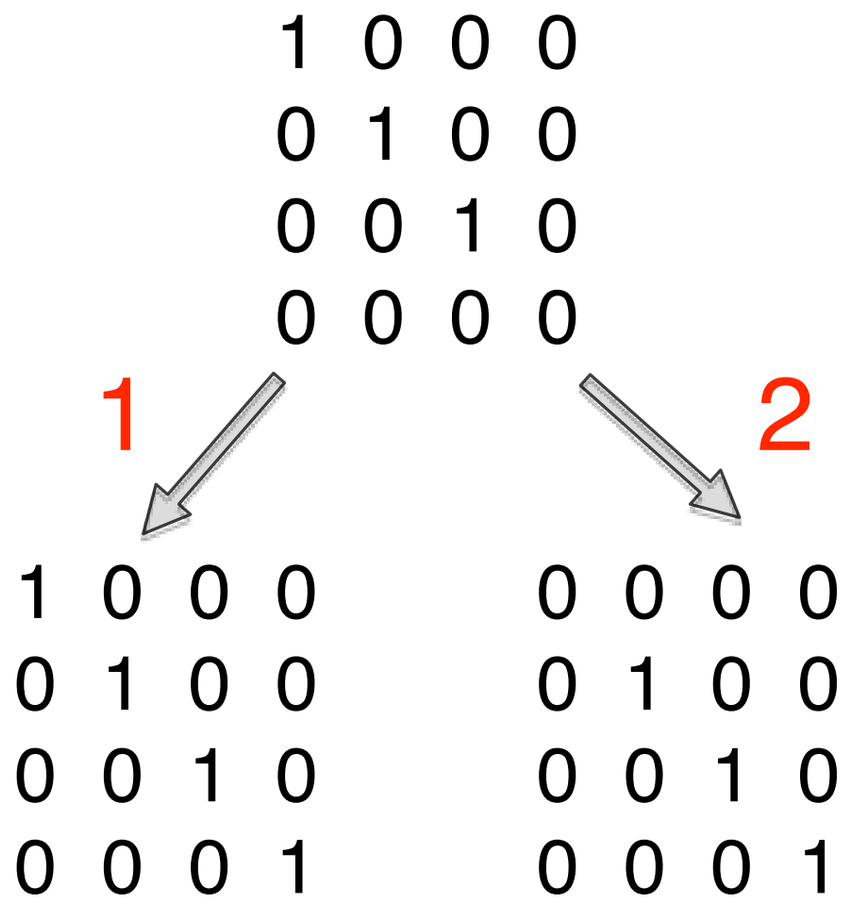


```
Warning: Matrix is close to singular or badly scaled.
         Results may be inaccurate. RCOND = 3.700743e-17.
> In eigs>AminusSigmaBsolve at 1204
  In eigs at 257
  In IleMod at 119
  In run at 69

Warning: Matrix is close to singular or badly scaled.
         Results may be inaccurate. RCOND = 3.700743e-17.
> In eigs>AminusSigmaBsolve at 1204
  In eigs at 257
  In IleMod at 119
  In run at 69
Done.
```

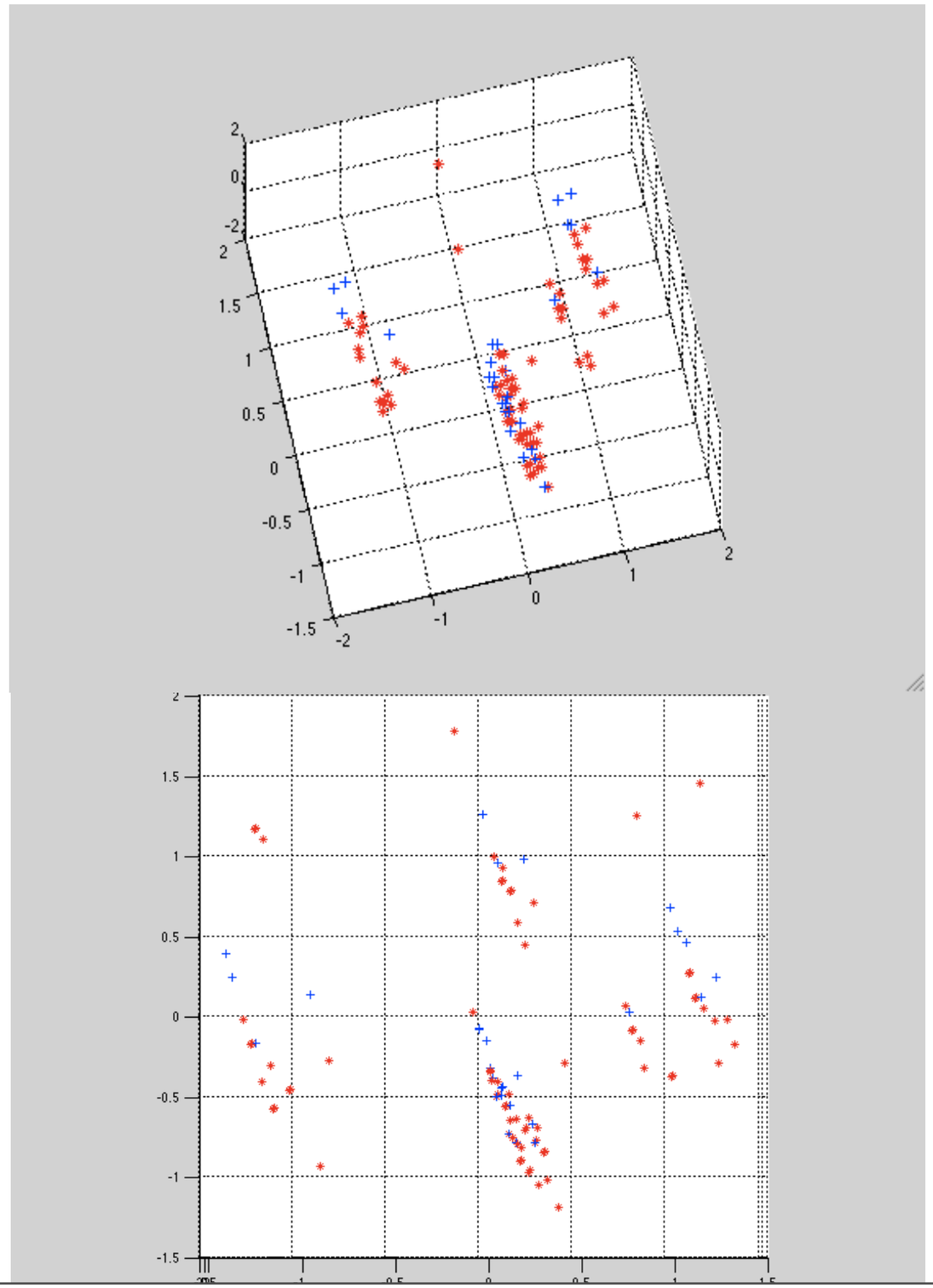
LLE - What's left?

- Assumption of locally linear data valid?
- AMPLE
- Distance metric definition
- Walk and Loiter distance



Principal Component Analysis

$$S = \begin{matrix} 5.6482 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 5.4354 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 4.6176 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 4.5500 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 3.9379 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 3.5706 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 2.5820 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2.3930 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2.2864 \end{matrix}$$



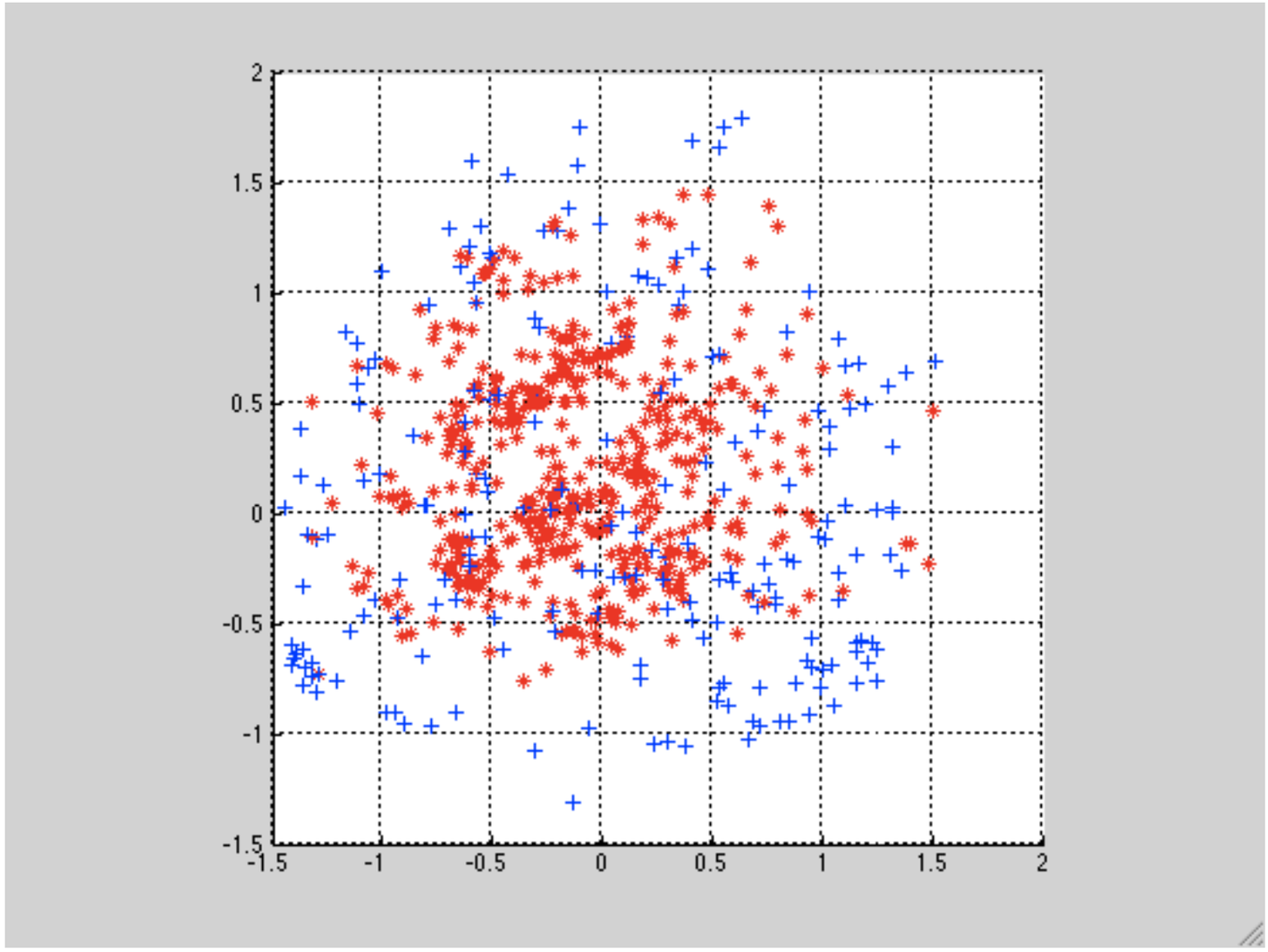
Dataset: (Dense)

1000 Points

100 Loitering Events

100 Walk Left Events

100 Walk Right Events



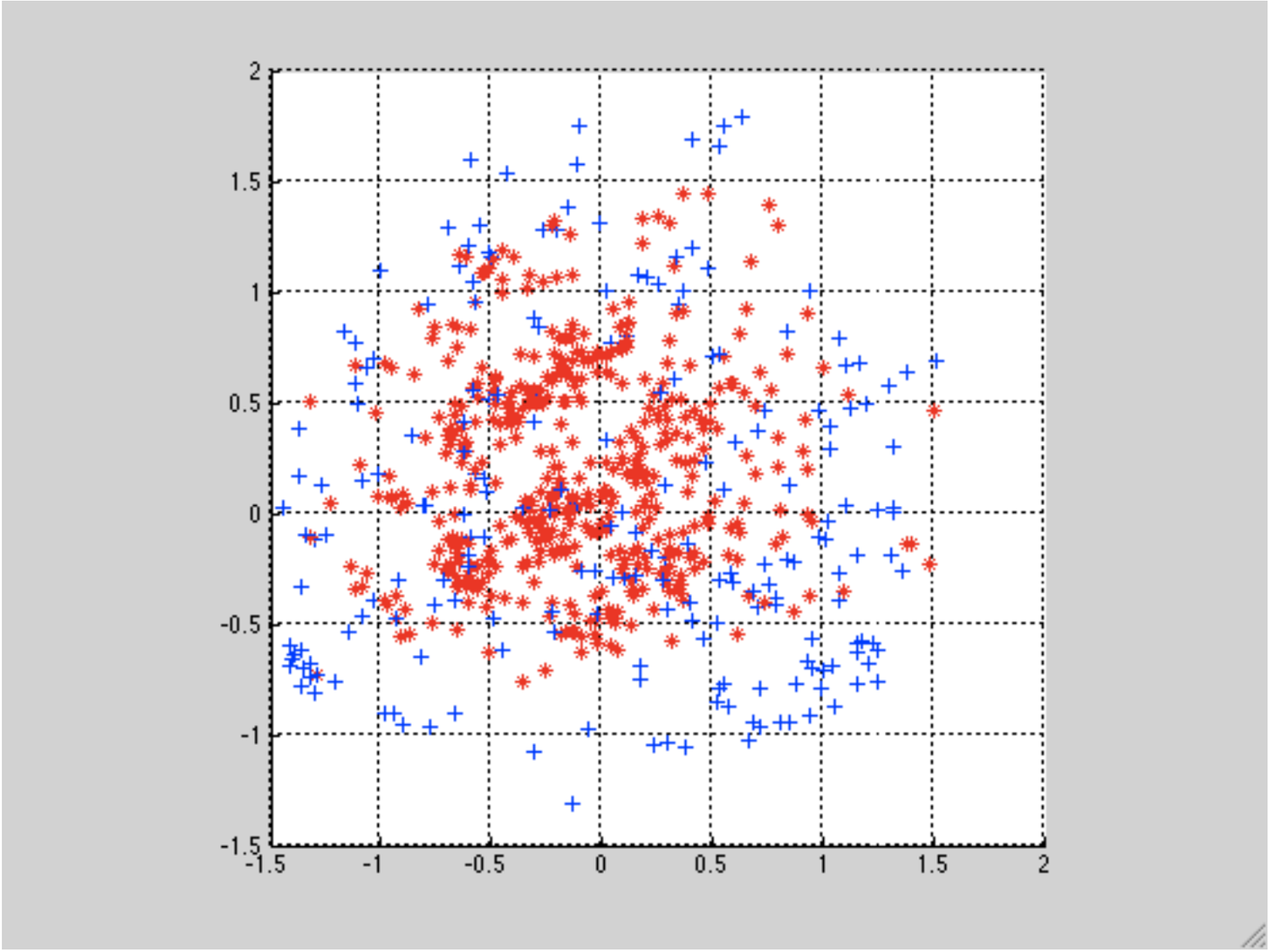
Dataset: (Sparse)

1000 Points

10 Loitering Events

10 Walk Left Events

10 Walk Right Events



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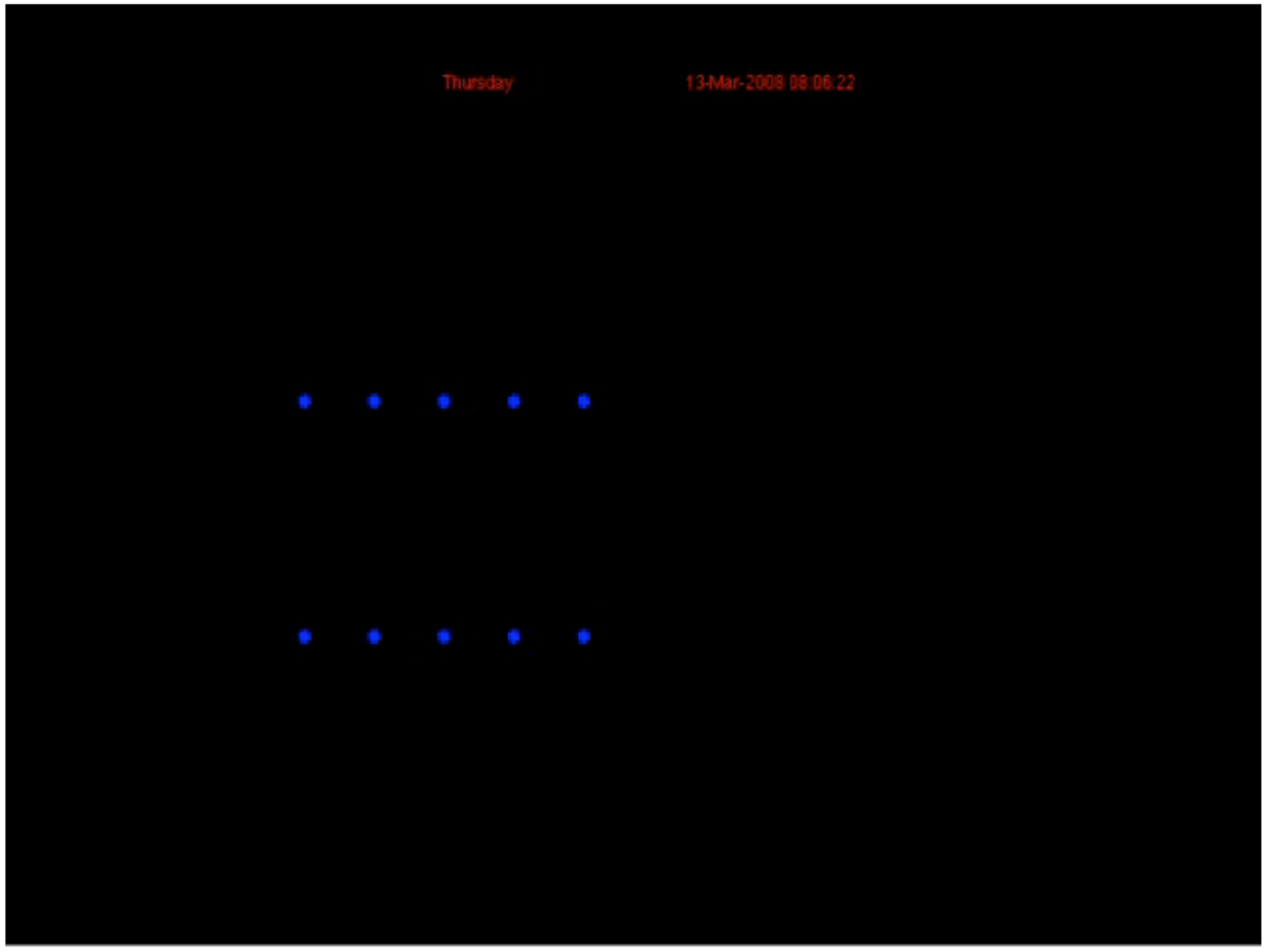
Closest Pattern Matching (CPM)

	0	0	0	0	0	0
	1	0	0	0	0	0
	0	1	1	0	1	1
	1	0	0	1	0	0
	1	0	0	1	1	1
	0	1	1	0	0	1
Predicted Row	0	1	1	0	0	0

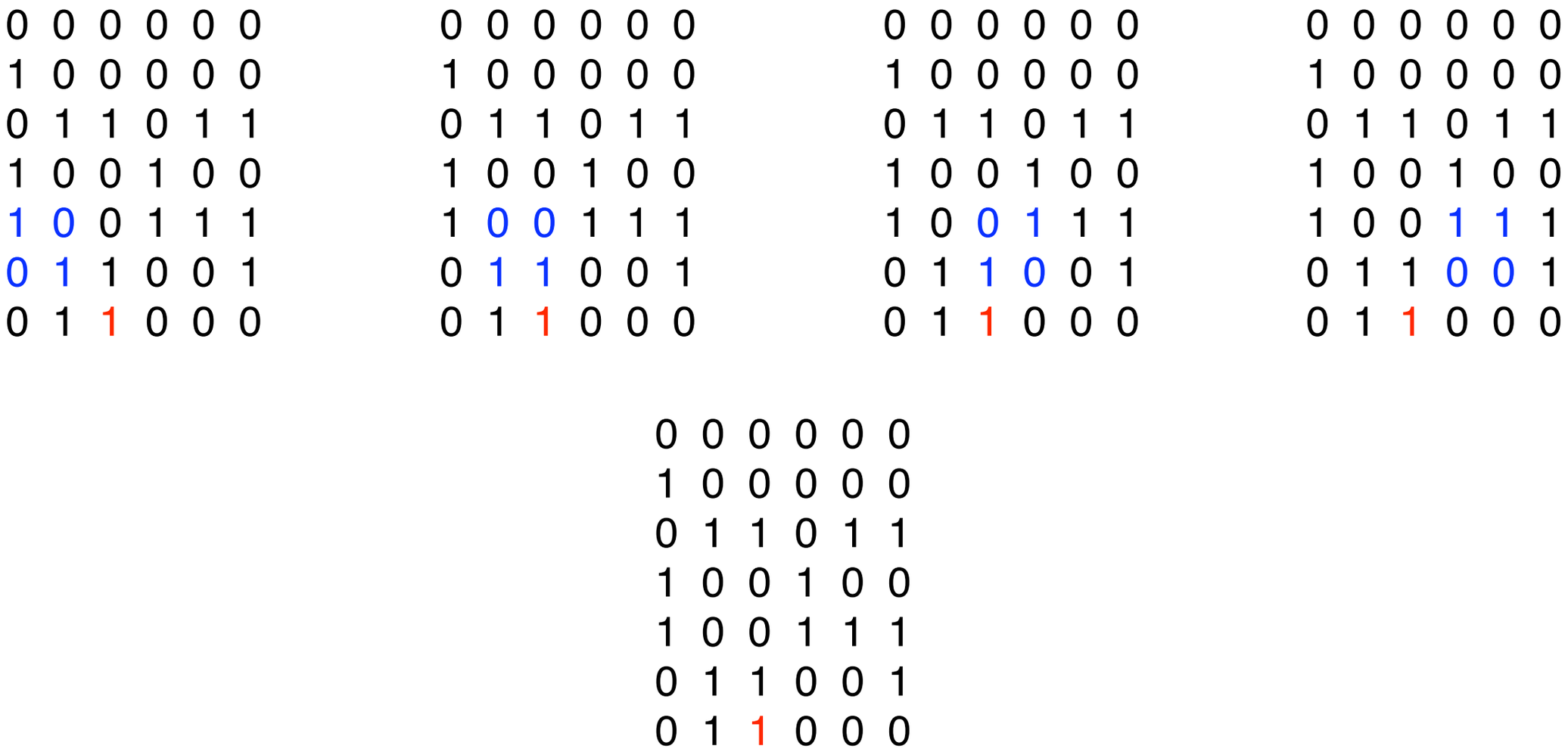
CPM - Continued

	0	0	0	0	0	0
	1	0	0	0	0	0
	0	1	1	0	1	1
	1	0	0	1	0	0
	1	0	0	1	1	1
	0	1	1	0	0	1
Predicted Row	0	1	1	0	0	0

CPM - Continued



Growing Pattern CPM

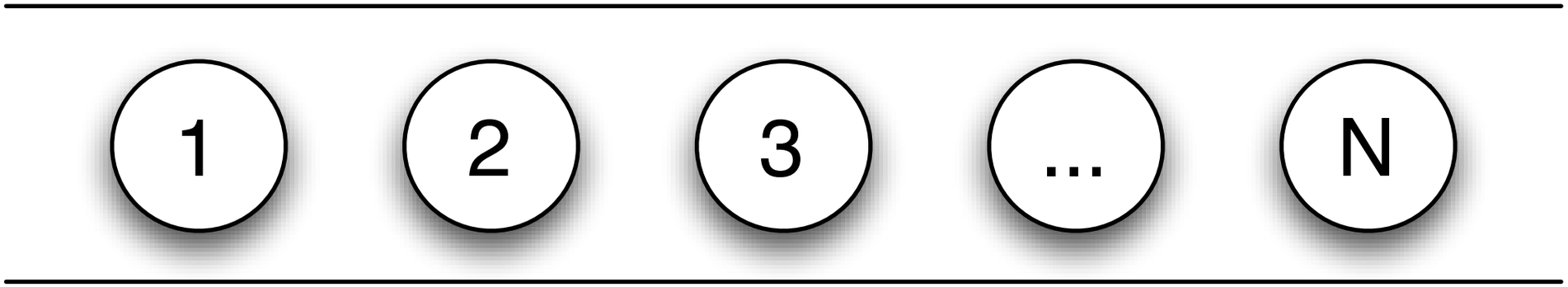


Growing Pattern CPM

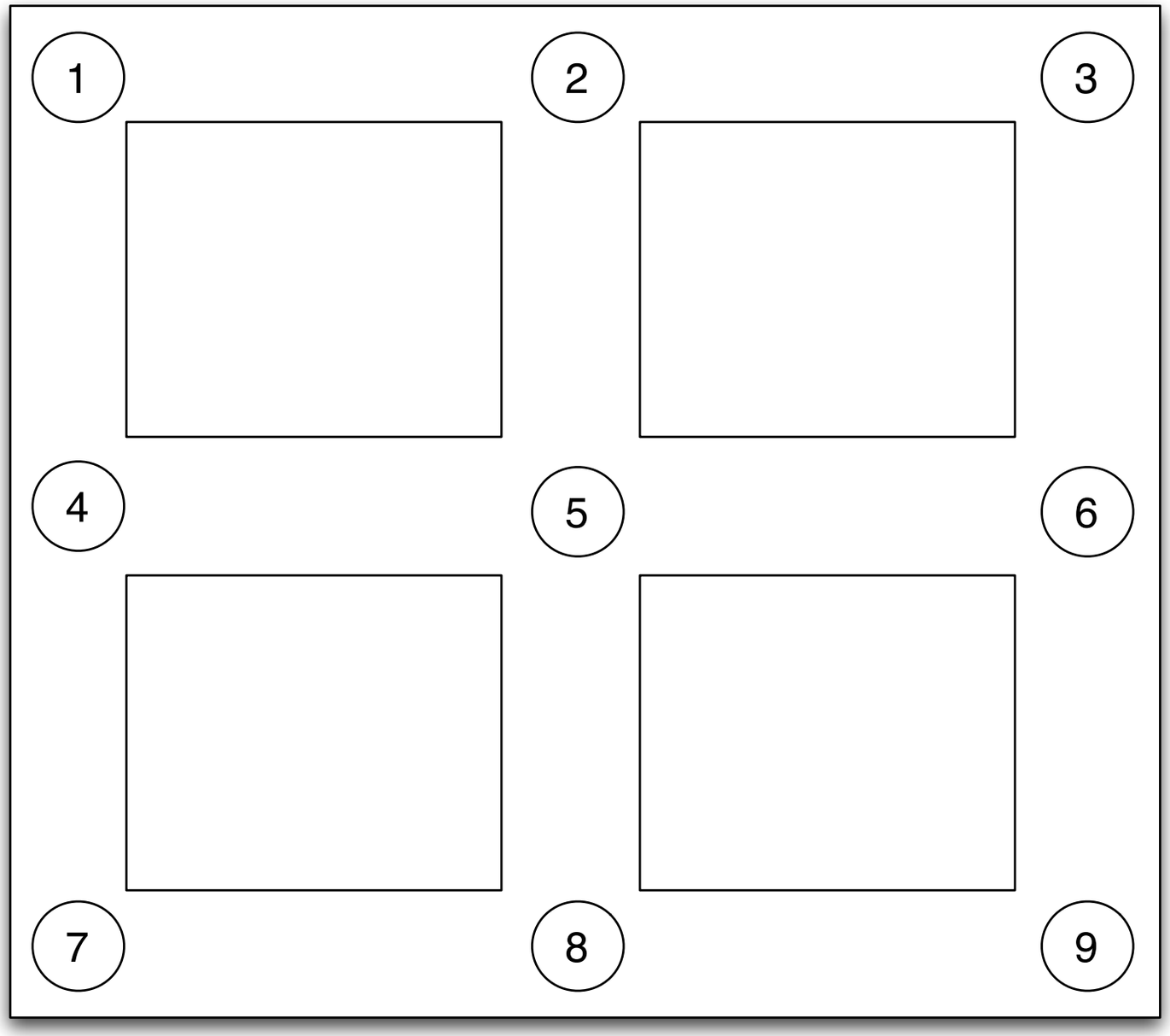
0 0 0 0 0 0
1 0 0 0 0 0
0 1 1 0 1 1
1 0 0 1 0 0
1 0 0 1 1 1
0 1 1 0 0 1
0 1 1 0 0 0

Growing Pattern CPM

CPM Problem

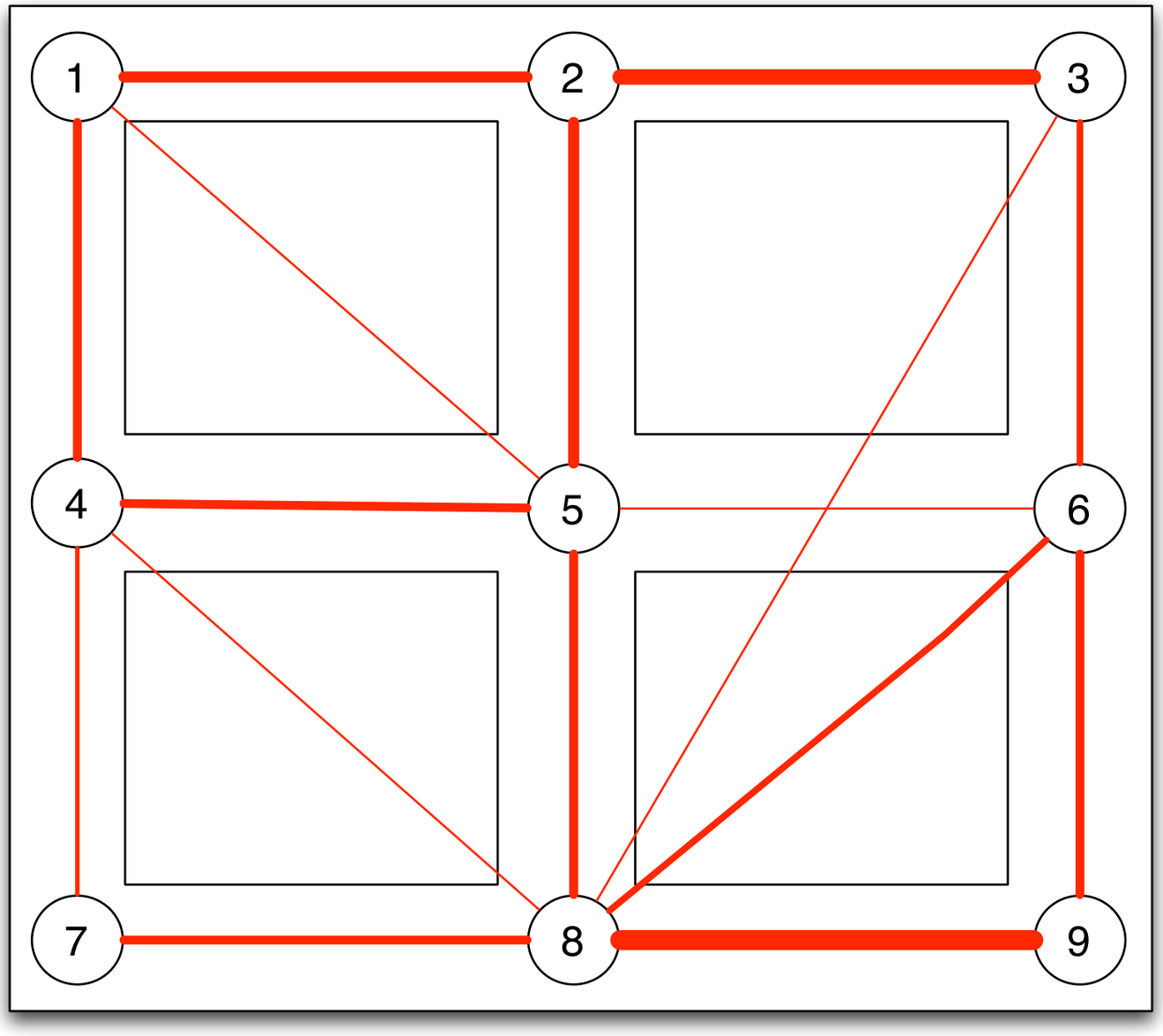


CPM - Problem



CPM - Current

Dynamically create patterns based on correlation score.



CPM - Current

- Construct a model per sensor
- Preprocess the data
    - Compress over time

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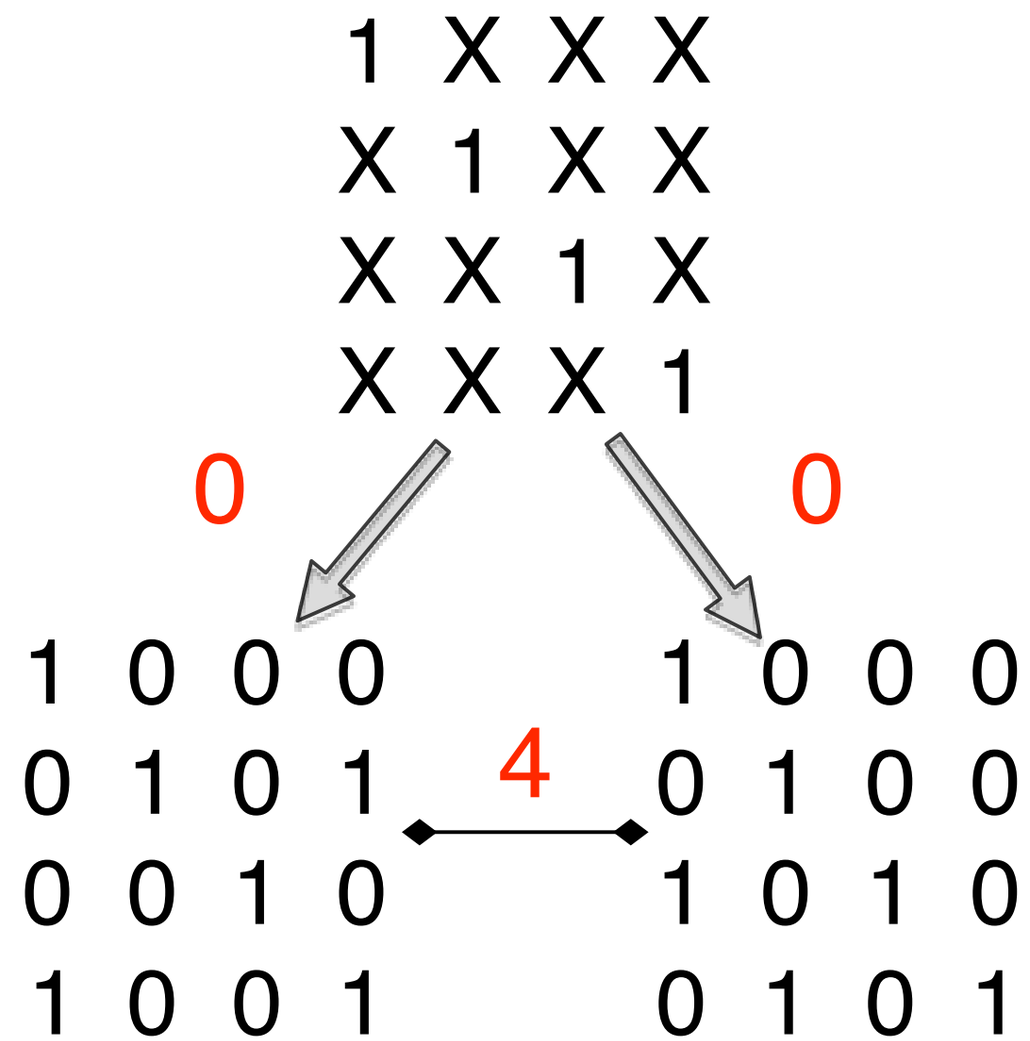
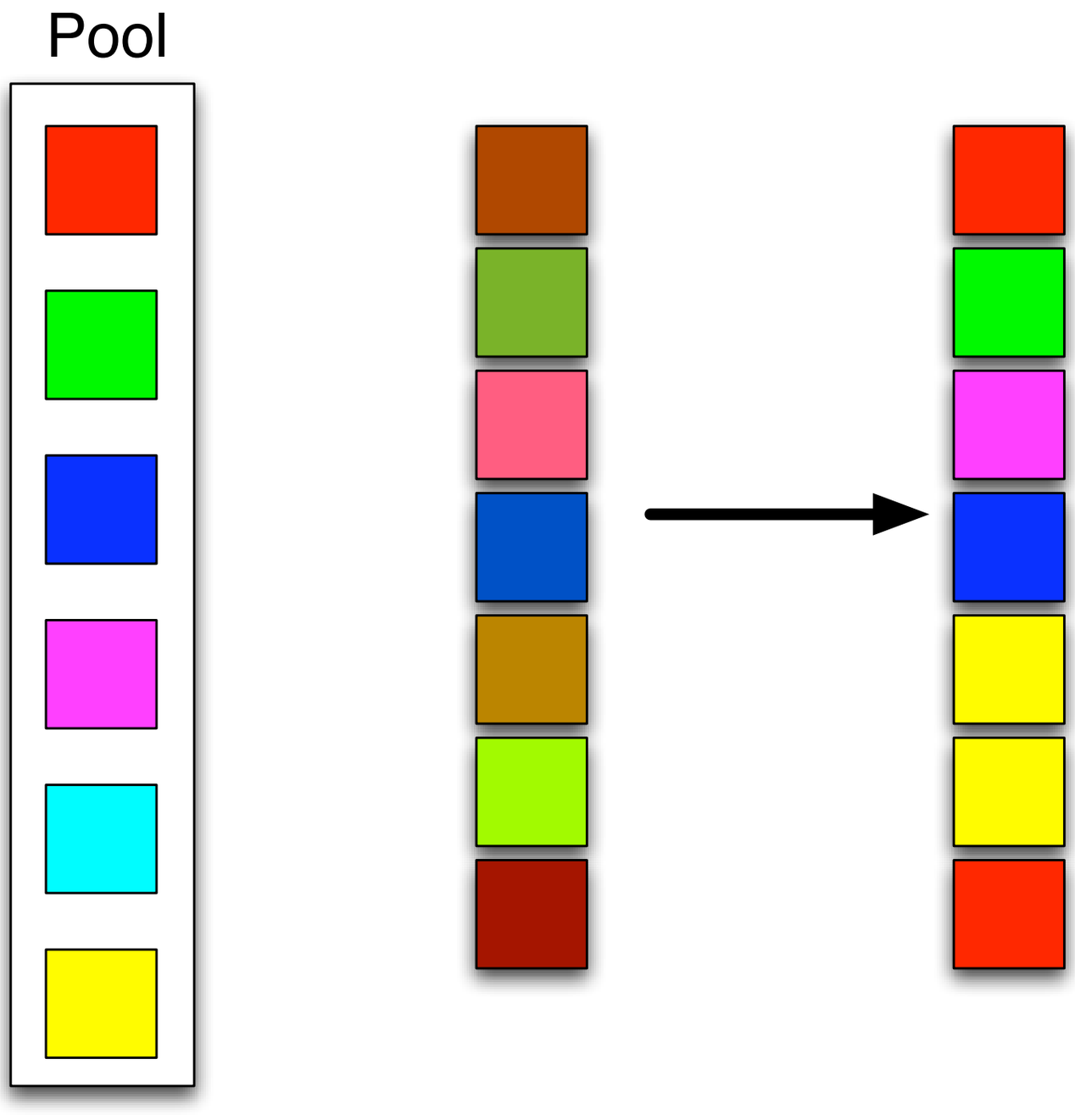
Minimum Description Length



Minimum Description Length



Minimum Description Length

- Demo by Bill

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What is an Anomaly

Context Discovery and Model Linking

- How can we define contexts using only state information?
  - Prior definition
  - Use a technique to dynamically create them.
    - Simulated Annealing with Latent Semantic Analysis as a move approximation metric

Non Pursued Paths

- Match previously defined activities to events in dataset
- Attempt to classify nodes dynamically if they exhibit behavior outside the defined realm.
- Utilizing some of the more standard Machine Learning algorithms