Unsupervised ML for Classification Problems

John Branch Bedoya
Pedro Atencio Ortiz

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UNIVERSIDAD
NACIONAL
DE COLOMBIA

Institución
Universitaria
Reacreditada en Alta Calidad

pedroatencio@itm.edu.co

Agenda

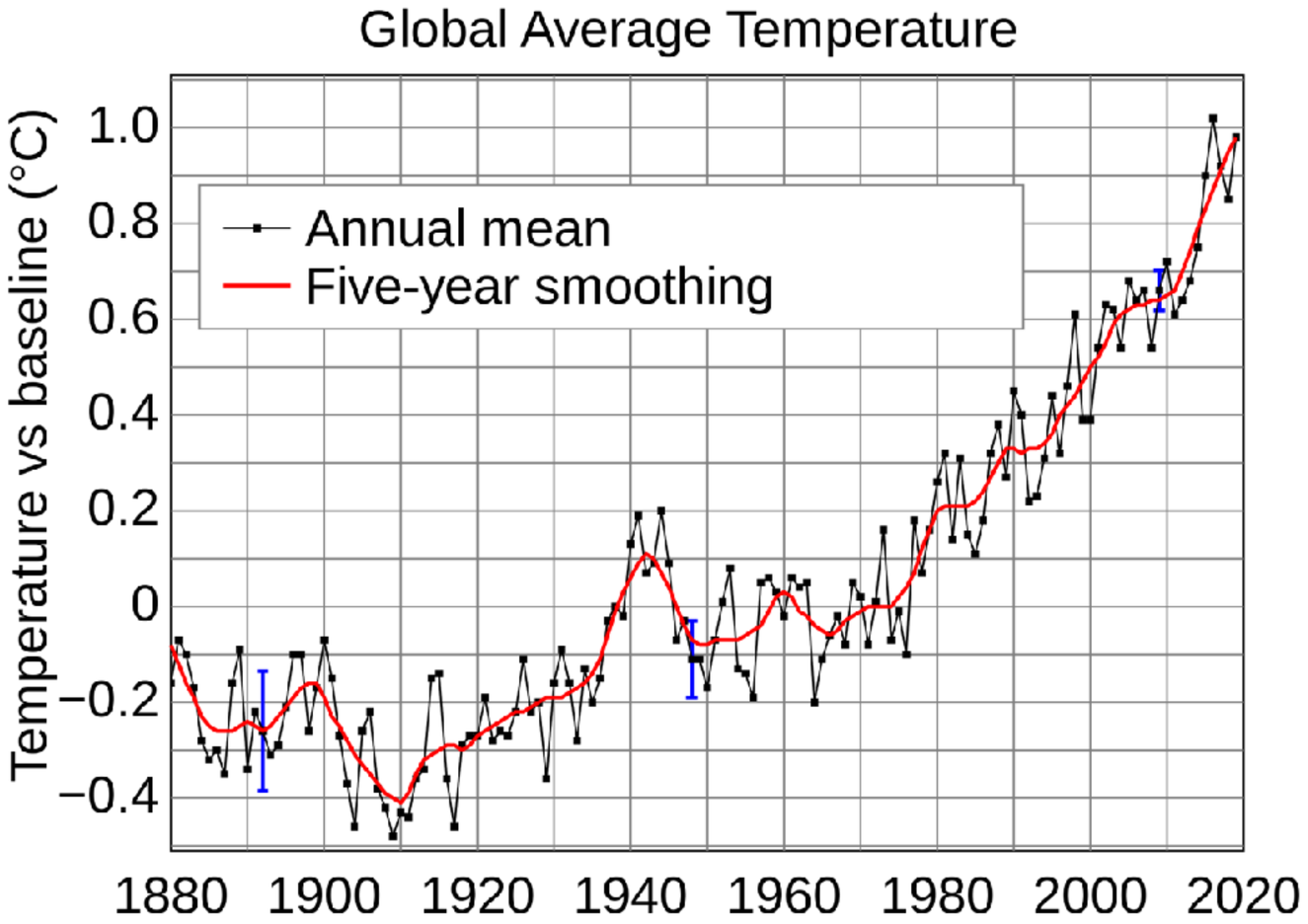
Session 3: Summarization of sequences

1. Sequences: Fundamentals.
2. Sequence Summarization.
    1. Extractive / Abstractive summarization.
    2. Applications.
3. Hierarchical Clustering.
4. Study case.
    1. Video Summarization.
5. Conclusions

1. Sequences: Fundamentals

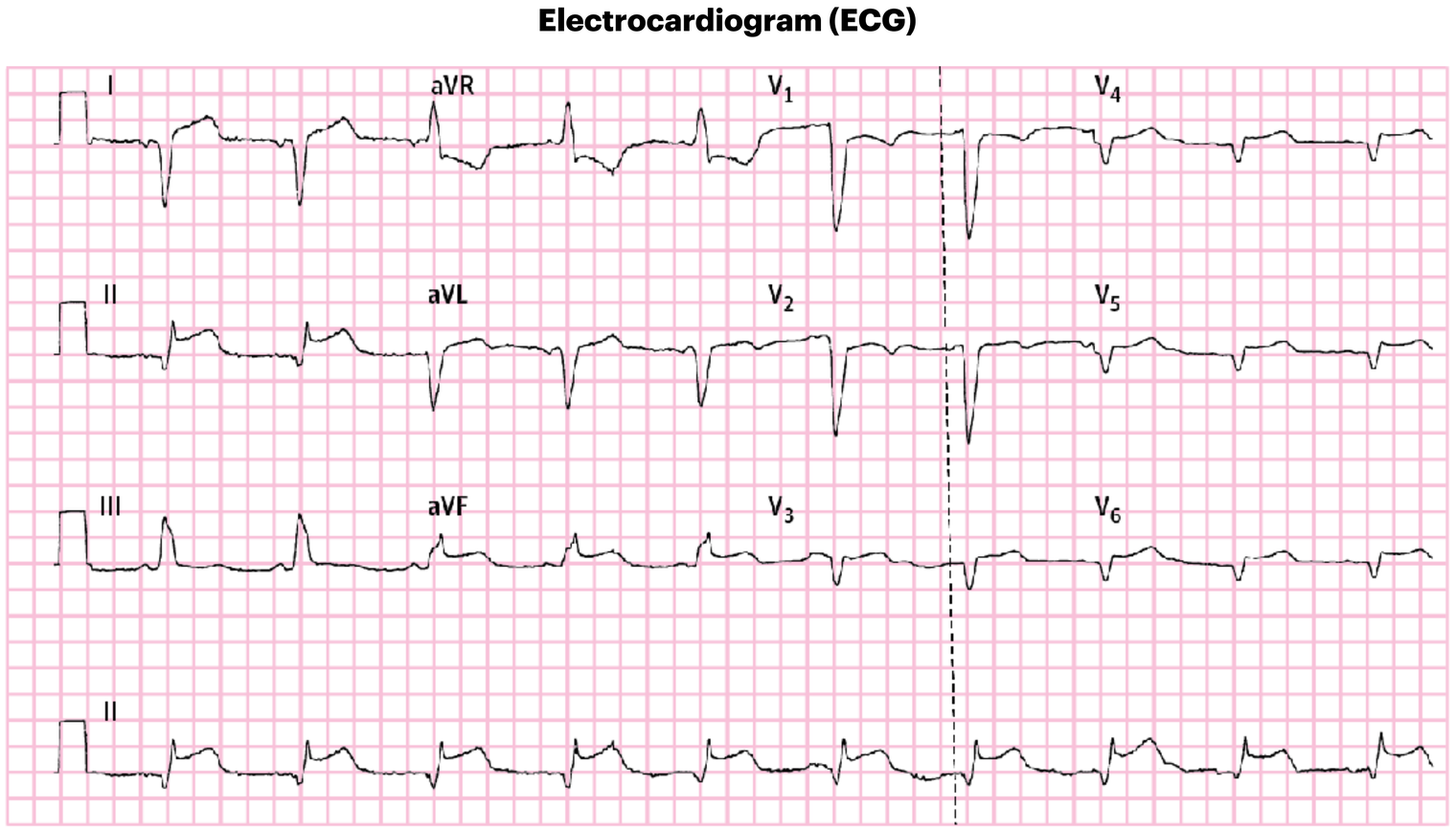
Time series

- Data indexed in time order.
- The concept of sample requires a time window.
- Commonly there is no (X, Y) pair but $(X_{[t-k,t]}, X_{[t+1]})$.
- Time series do not mean regression. Classification in also possible.



Time series

- Can be univariate or multivariate.
- Can be 1-dimensional o n-dimensional.



Sequence

- Can be univariate or multivariate.
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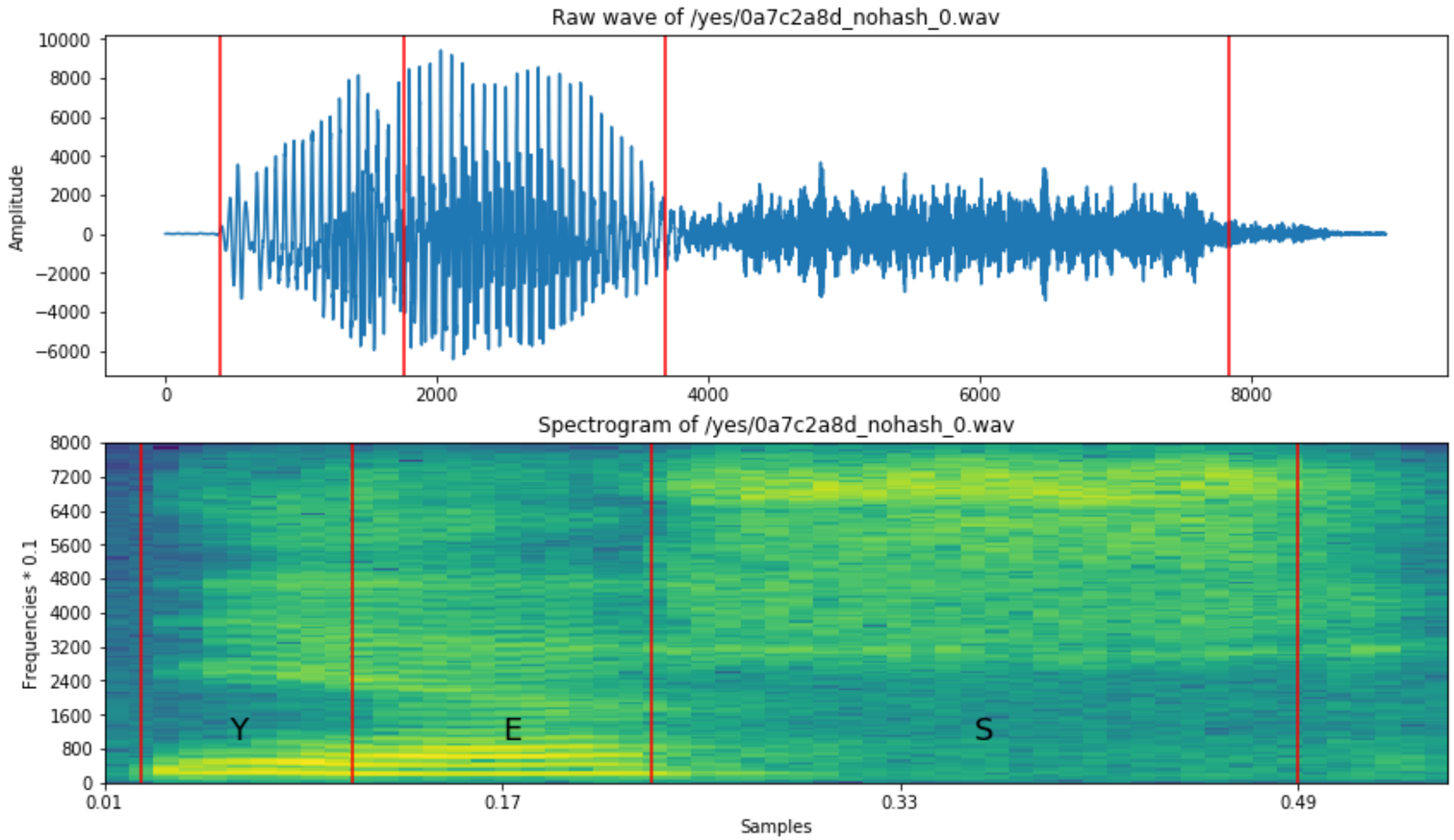
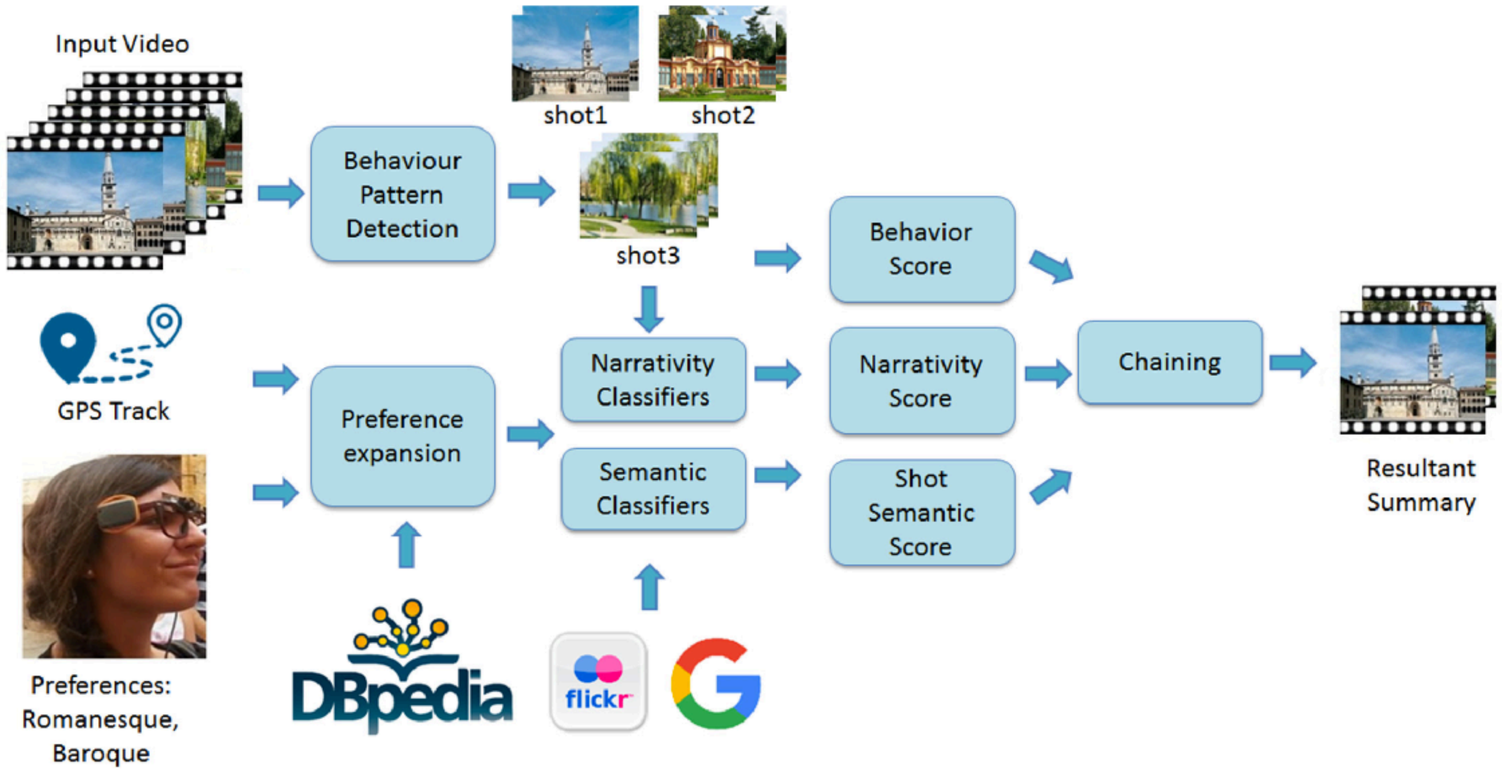


Sequence

- Time is not always clear, but order.
- Words in a text can be considered a sequence, not in time but in order.

Sequence

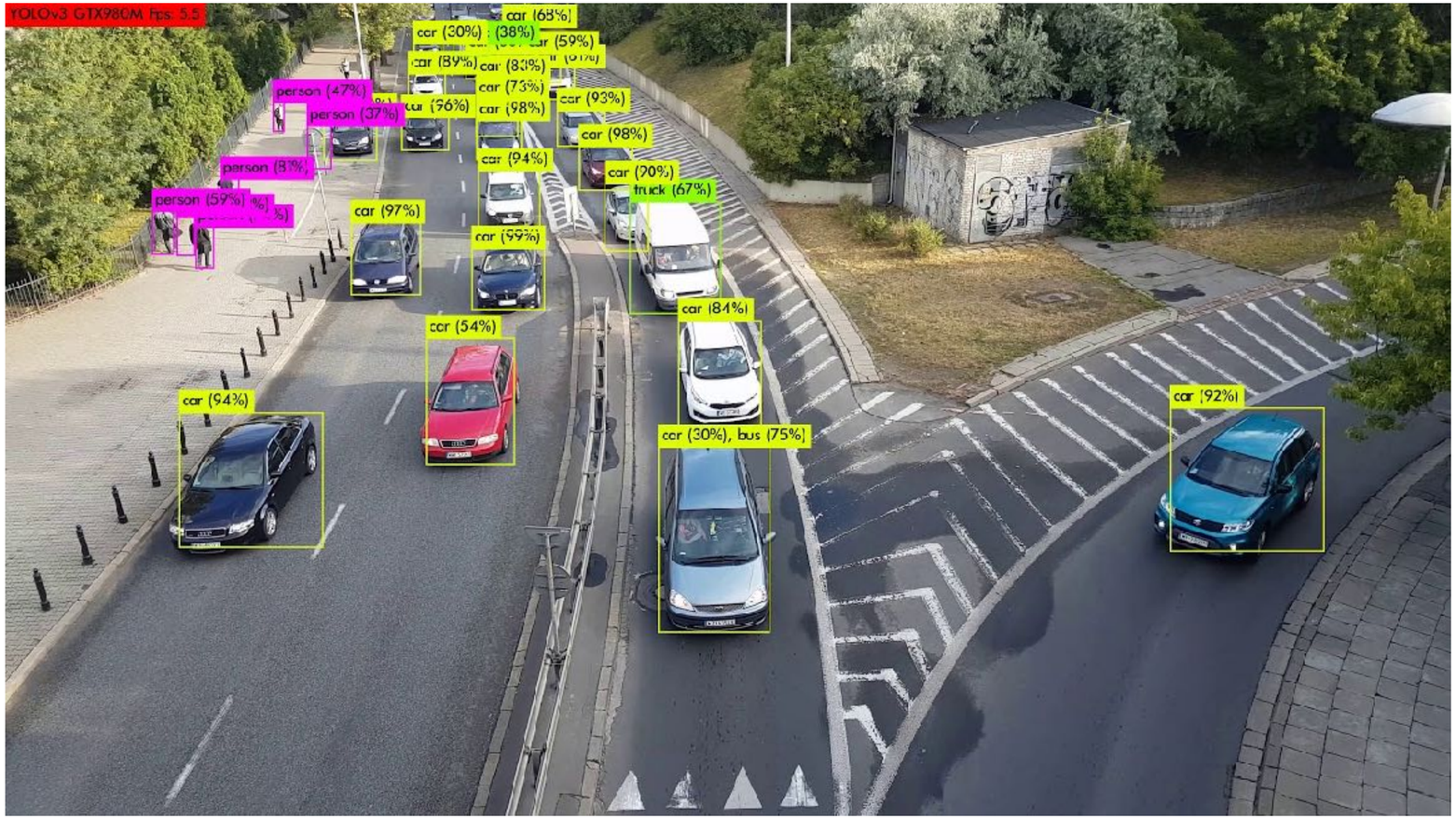
- Can be multimodal.
- **Multimodality**: same phenomena, observations from different sensors / sources.



(Varini et.al., 2017) Personalized Egocentric Video Summarization of Cultural Tour on User Preferences Input

Sequence

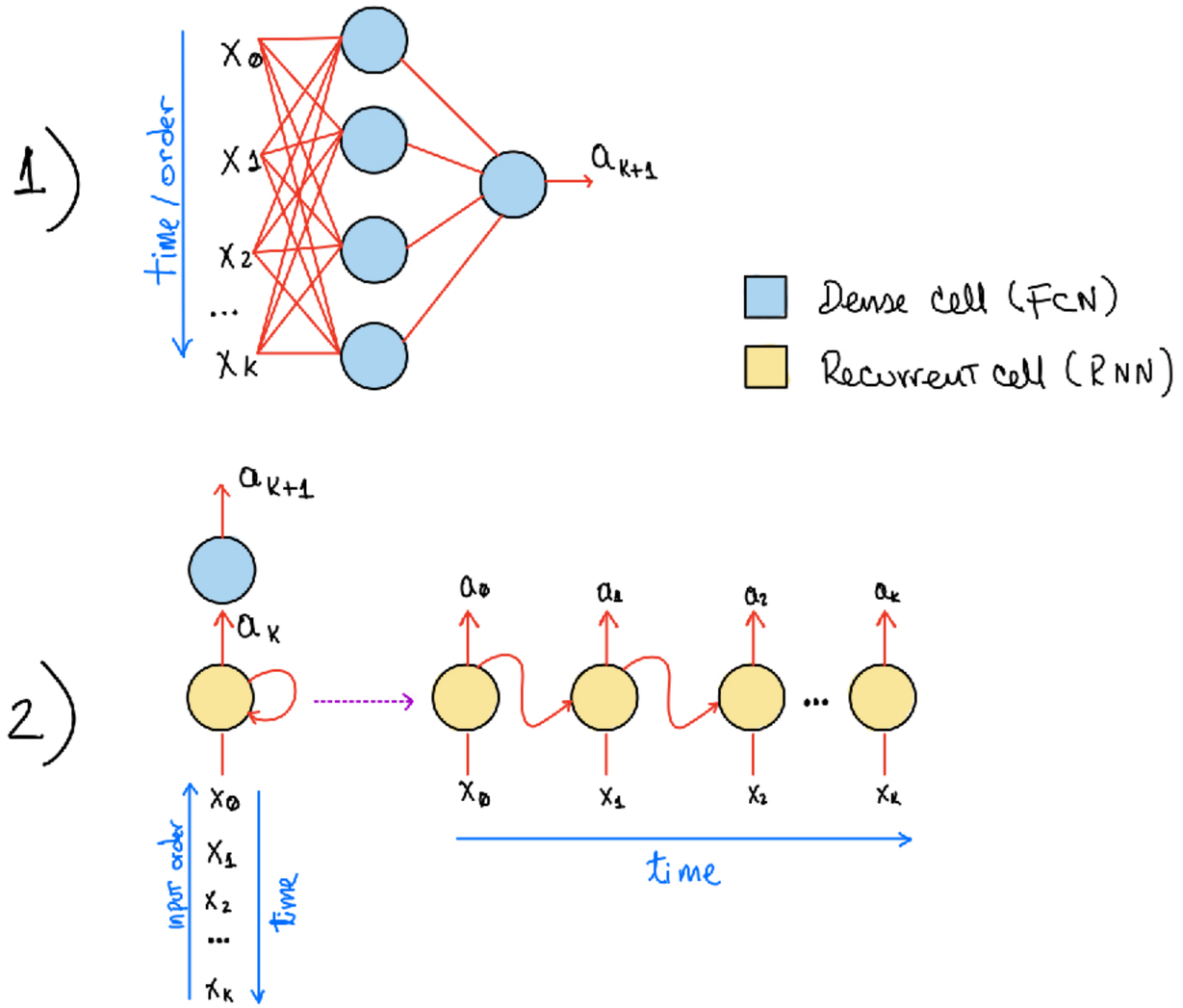
- Sometimes simplification, compression or summarization is required.
- e.g. Bounding boxes and labels instead of images in order to predict accidents.



Sequence processing

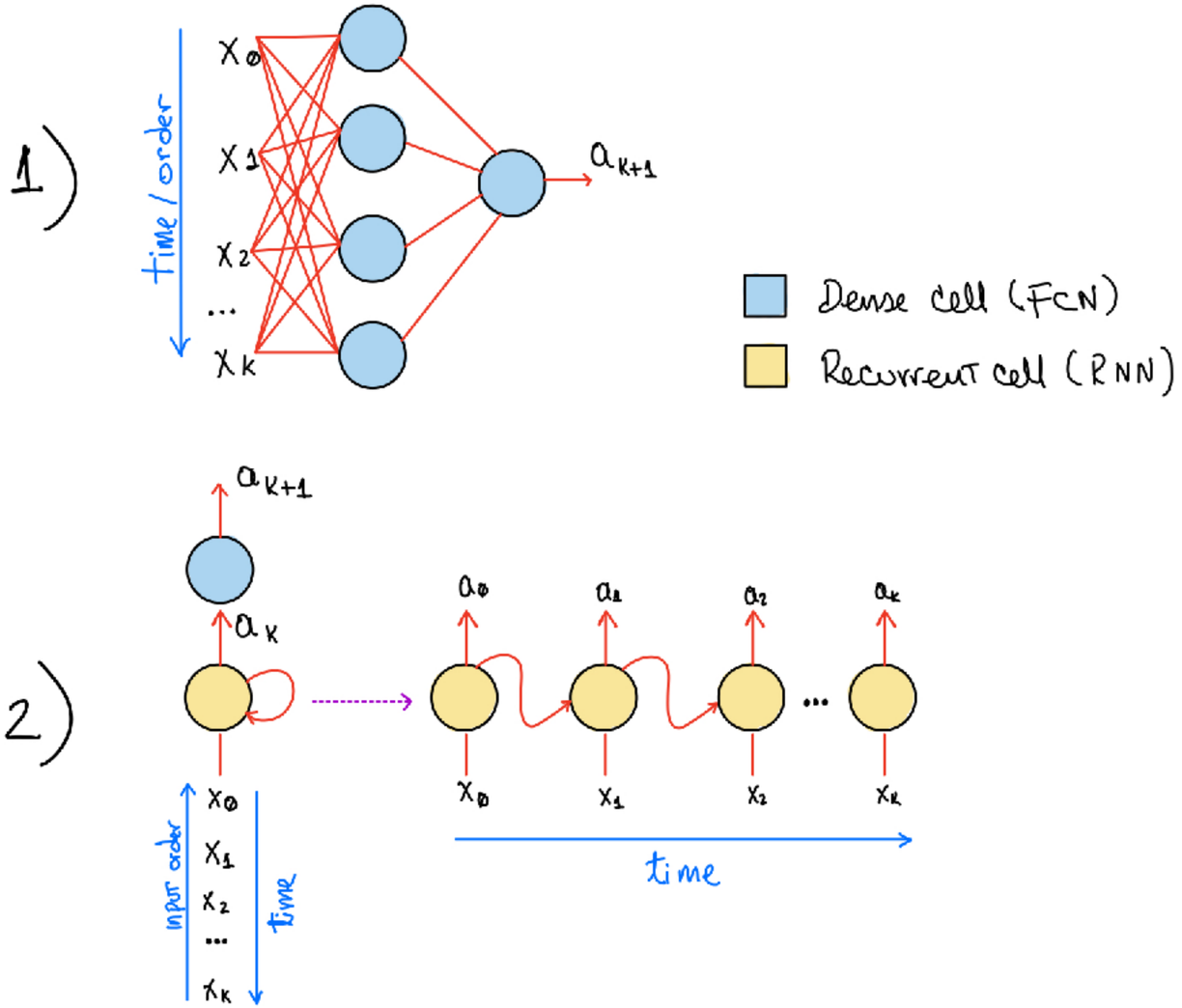
- 1) Each sample x_i in a serie is taken as an independent input of a FCN (dense) network.

- 2) Each sample x_i in a serie is sequentially inputted in a recurrent layer. The output of the recurrent layer is taken as the input of a dense layer.



Sequence processing

[Explore time series processing with Keras.]



Study case: Video classification

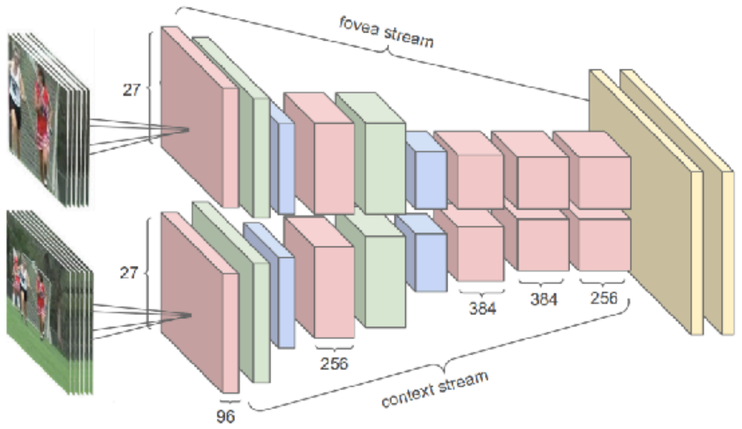
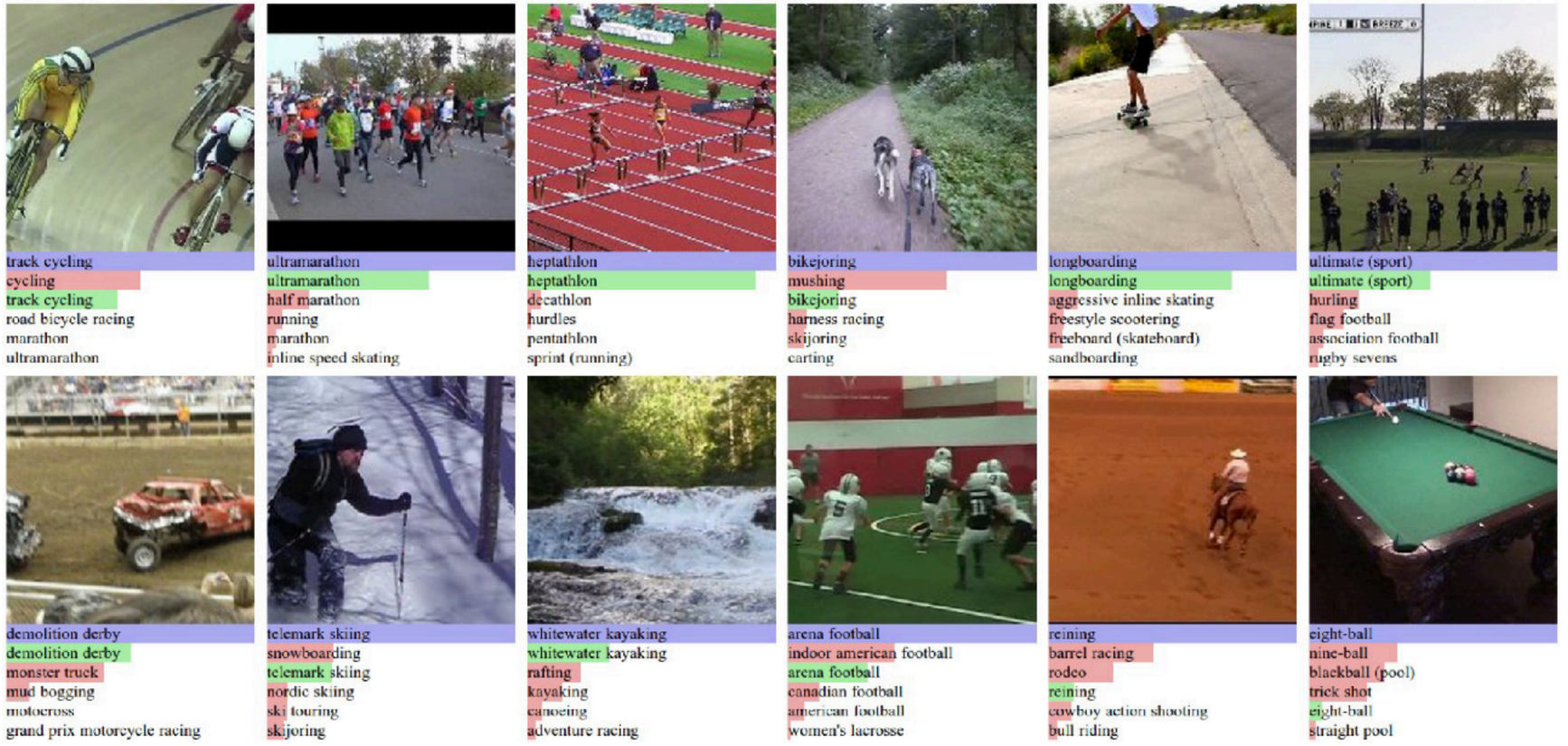


Figure 2: Multiresolution CNN architecture. Input frames are fed into two separate streams of processing: a *context stream* that models low-resolution image and a *fovea stream* that processes high-resolution center crop. Both streams consist of alternating convolution (red), normalization (green) and pooling (blue) layers. Both streams converge to two fully connected layers (yellow).

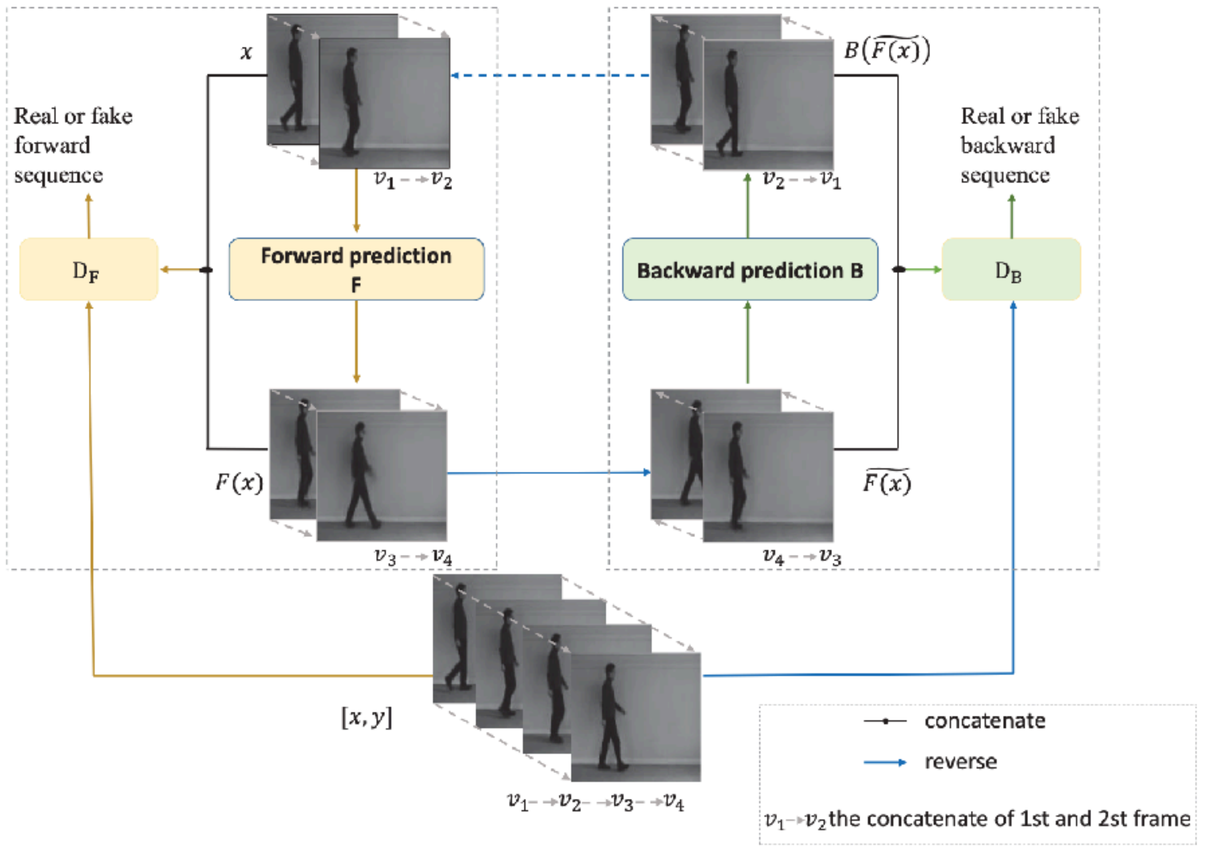
(Karpathy et. al. , 2014) Large-scale Video Classification with Convolutional Neural Networks.

Study case: Video classification



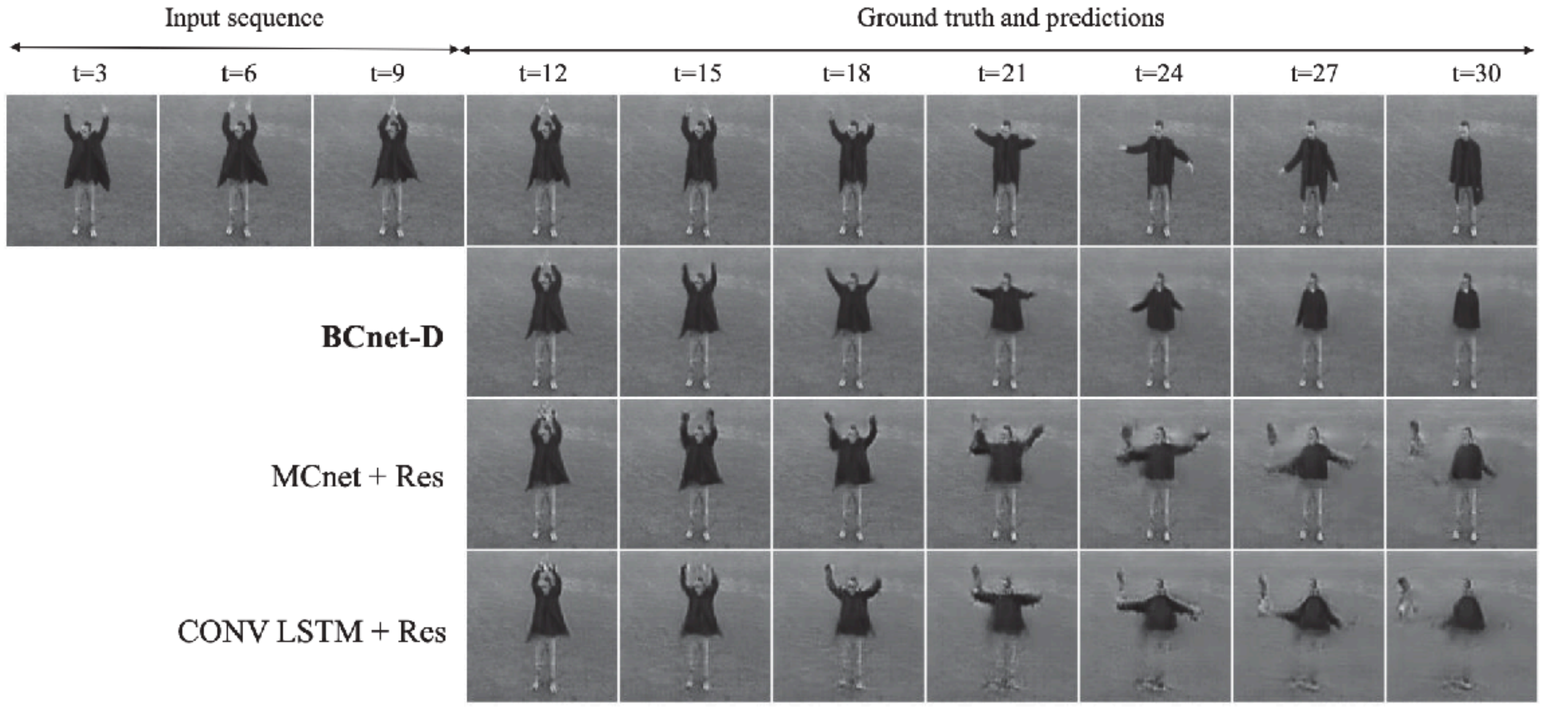
(Karpathy et. al. , 2014) Large-scale Video Classification with Convolutional Neural Networks.

Study case: Video prediction



(Hou et. al. , 2019) Video Prediction with Bidirectional Constraint Network .

Study case: Video prediction



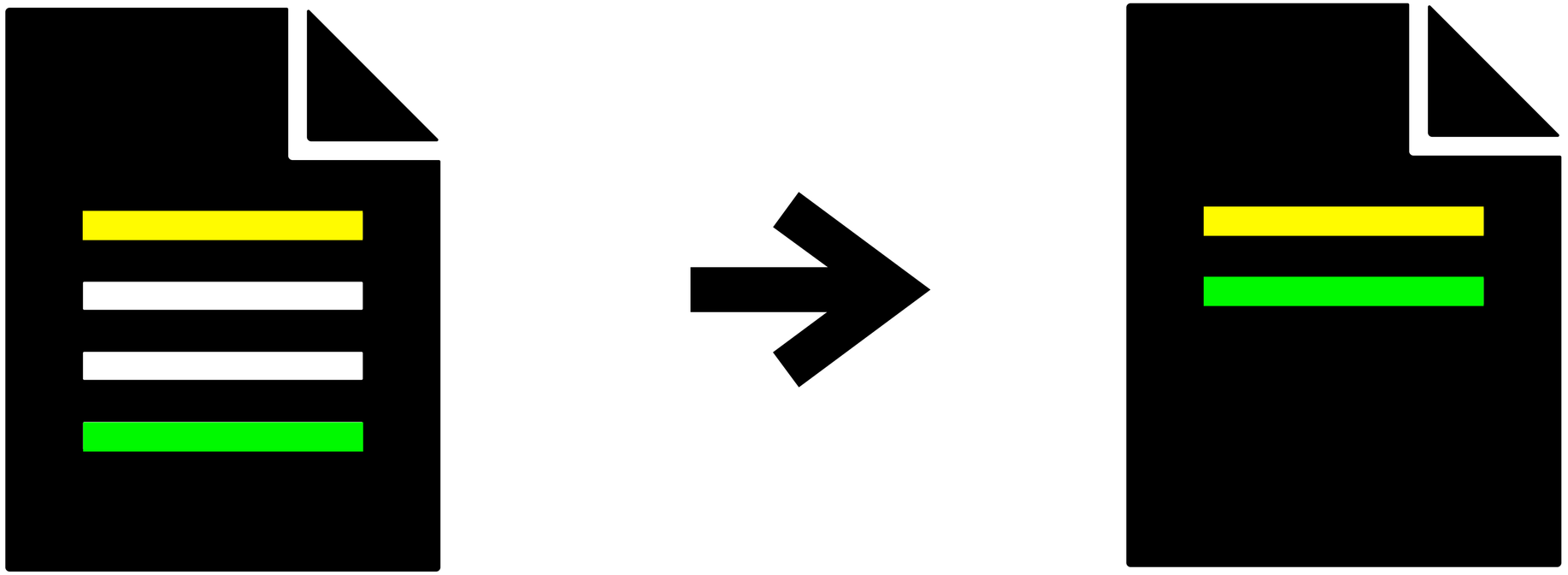
(b) Hand-Waving

Fig. 8. Prediction samples from KTH dataset. We display predictions starting from the 12^{th} frame, in every 3 time steps.

(Hou et. al. , 2019) Video Prediction with Bidirectional Constraint Network .

2. Sequence Summarization

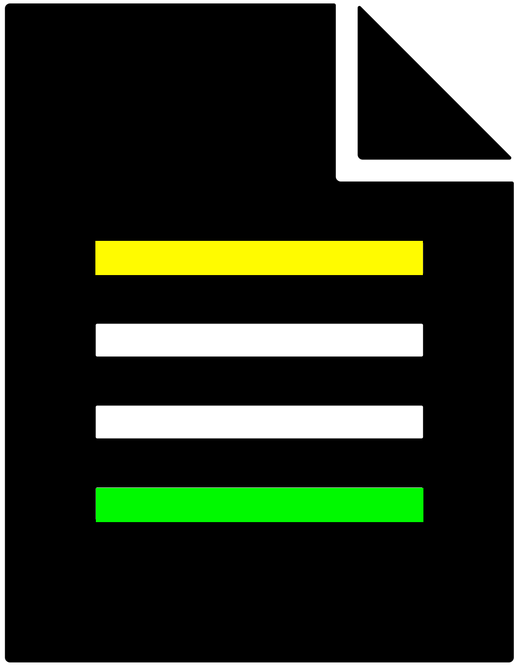
Extractive Summarization



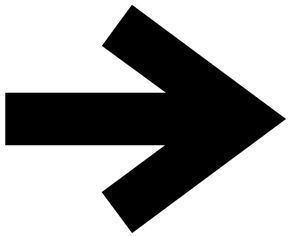
Input text

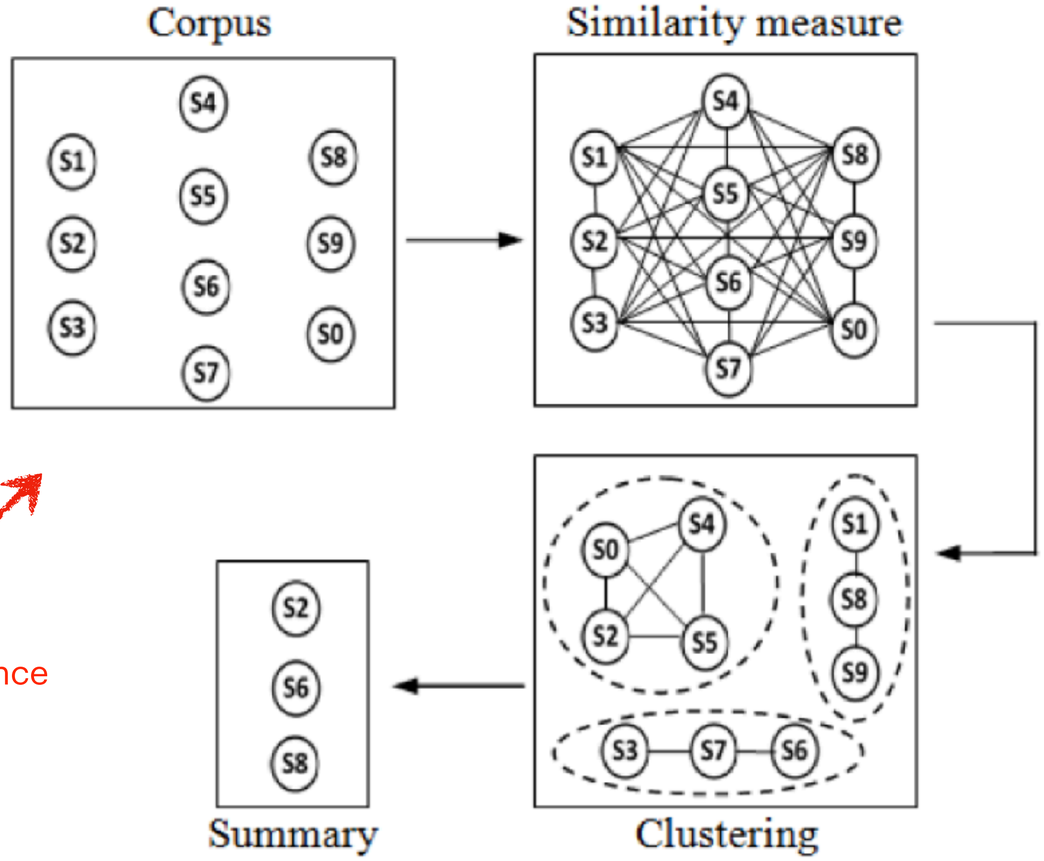
Summary

Extractive Summarization



Input text

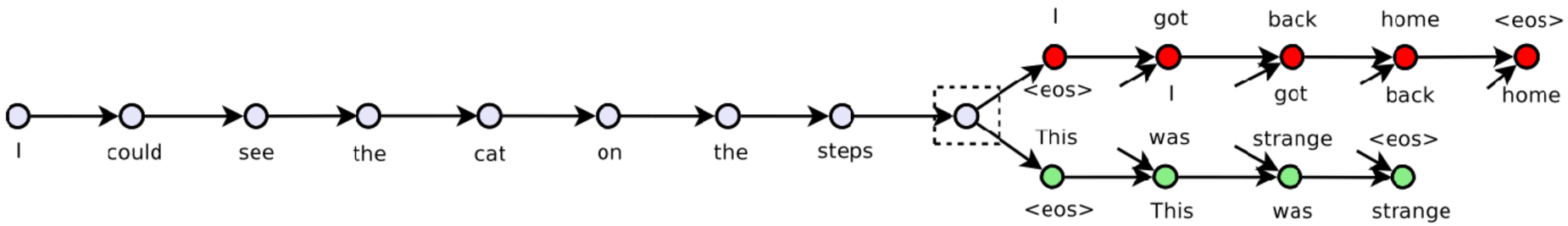




It is required a sentence representation

(Kumar et. al. , 2016) A Review on Automatic Text Summarization Approaches.

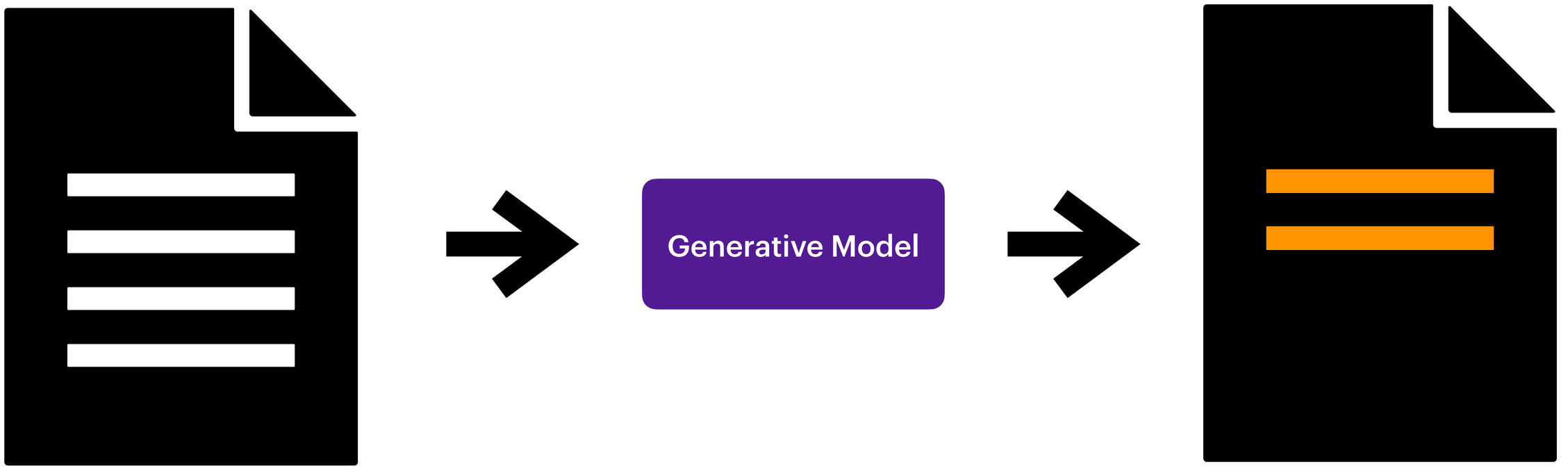
Sentence Embedding: Skip-thought vectors



Query and nearest sentence
he ran his hand inside his coat , double-checking that the unopened letter was still there . he slipped his hand between his coat and his shirt , where the folded copies lay in a brown envelope .
im sure youll have a glamorous evening , she said , giving an exaggerated wink . im really glad you came to the party tonight , he said , turning to her .
although she could tell he had n't been too invested in any of their other chitchat , he seemed genuinely curious about this . although he had n't been following her career with a microscope , he 'd definitely taken notice of her appearances .
an annoying buzz started to ring in my ears , becoming louder and louder as my vision began to swim . a weighty pressure landed on my lungs and my vision blurred at the edges , threatening my consciousness altogether .

(Kiros et. al. , 2015) Skip-thought vectors.

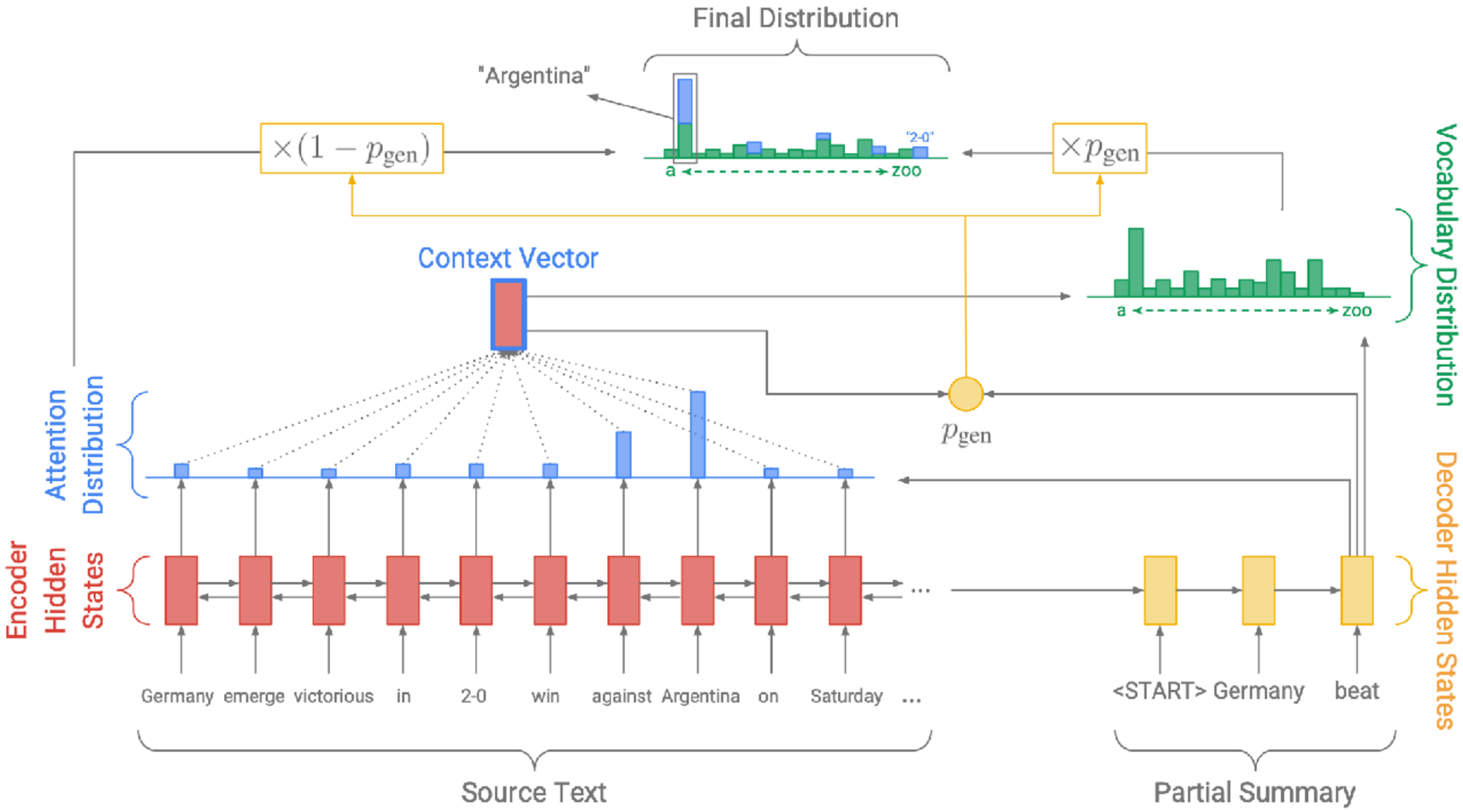
Abstractive Summarization



Input text

Summary

Abstractive Summarization



(See et. al. , 2017) Get To The Point: Summarization with Pointer-Generator Networks.

Abstractive Summarization

Original Text (truncated): lagos, nigeria (cnn) a day after winning nigeria's presidency, ***muhammadu buhari*** told cnn's christiane amanpour that **he plans to aggressively fight corruption that has long plagued nigeria** and go after the root of the nation's unrest. *buhari* said he'll "rapidly give attention" to curbing violence in the northeast part of nigeria, where the terrorist group boko haram operates. by cooperating with neighboring nations chad, cameroon and niger, **he said his administration is confident it will be able to thwart criminals** and others contributing to nigeria's instability. for the first time in nigeria's history, the opposition defeated the ruling party in democratic elections. *buhari* defeated incumbent goodluck jonathan by about 2 million votes, according to nigeria's independent national electoral commission. **the win comes after a long history of military rule, coups and botched attempts at democracy in africa's most populous nation.**

Baseline Seq2Seq + Attention: **UNK UNK** says his administration is confident it will be able to **destabilize nigeria's economy**. **UNK** says his administration is confident it will be able to thwart criminals and other **nigerians**. **he says the country has long nigeria and nigeria's economy.**

Pointer-Gen: *muhammadu buhari* says he plans to aggressively fight corruption **in the northeast part of nigeria**. he says he'll "rapidly give attention" to curbing violence **in the northeast part of nigeria**. he says his administration is confident it will be able to thwart criminals.

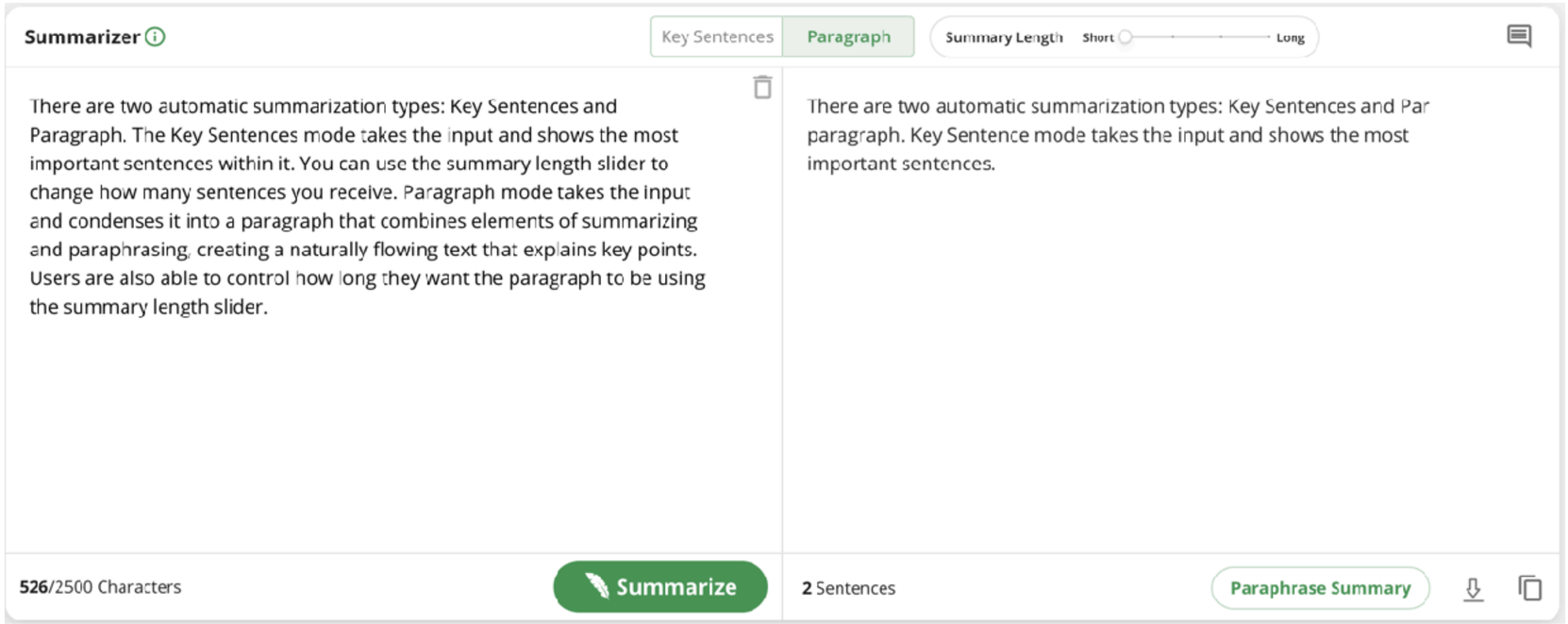
Pointer-Gen + Coverage: *muhammadu buhari* says he plans to aggressively fight corruption that has long plagued nigeria. he says his administration is confident it will be able to thwart criminals. the win comes after a long history of military rule, coups and botched attempts at democracy in africa's most populous nation.

(See et. al. , 2017) Get To The Point: Summarization with Pointer-Generator Networks.

Applications

Text summarization

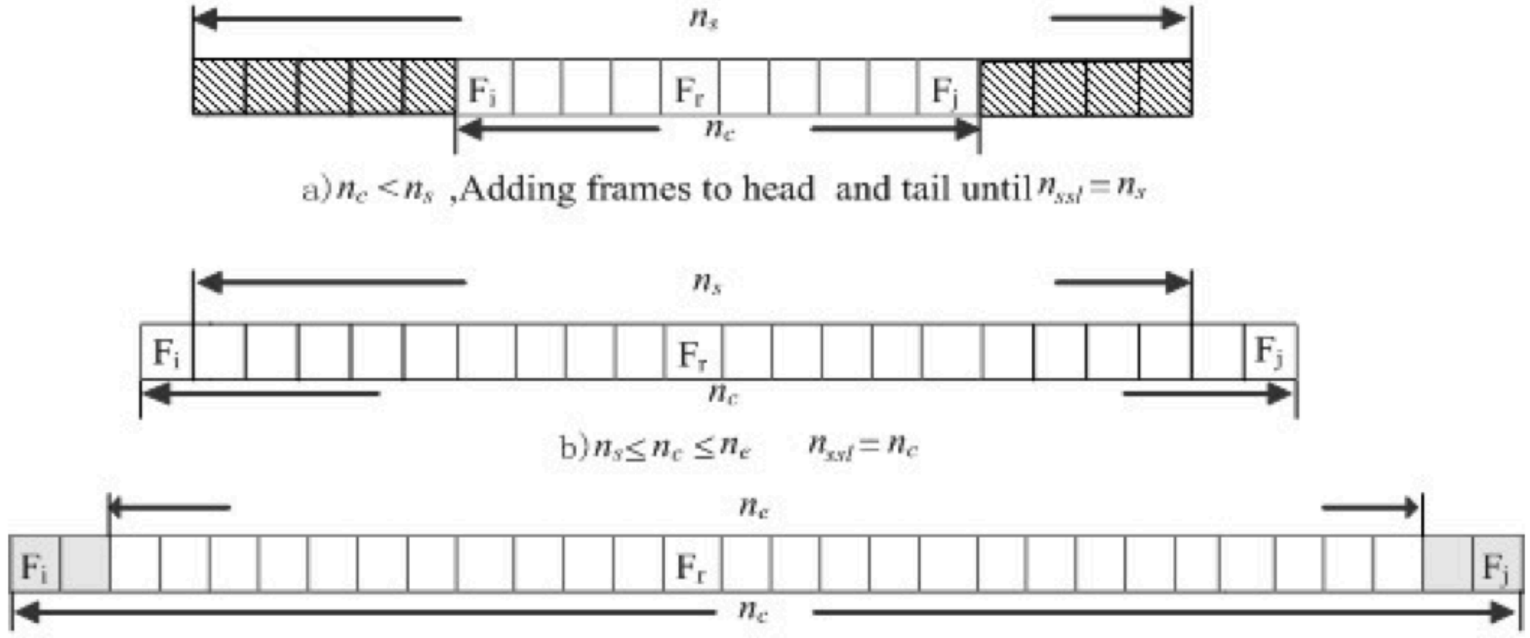
- **Input**: arbitrary-length text.
- **Output**: shorter text.
- **Applications**: Data mining, document analysis, chat-bots, Grammarly, document indexing / retrieval.



Applications

Music summarization

- **Input**: arbitrary-length audio.
- **Output**: shorter audio, preserving prologue+main+epilogue.
- **Applications**: Computer-aided music composition, music indexing, content-based music retrieval.



(Xu et. al. , 2004) Automatically Summarize Musical Audio Using Adaptive Clustering.

Applications

Video summarization

- **Input**: arbitrary-length video.
- **Output**: shorter video, preserving main and most important scenes.
- **Applications**: Video analysis, video indexing, content-based video retrieval.

(Gigly et.al. , 2014) Creating Summaries from User Videos.

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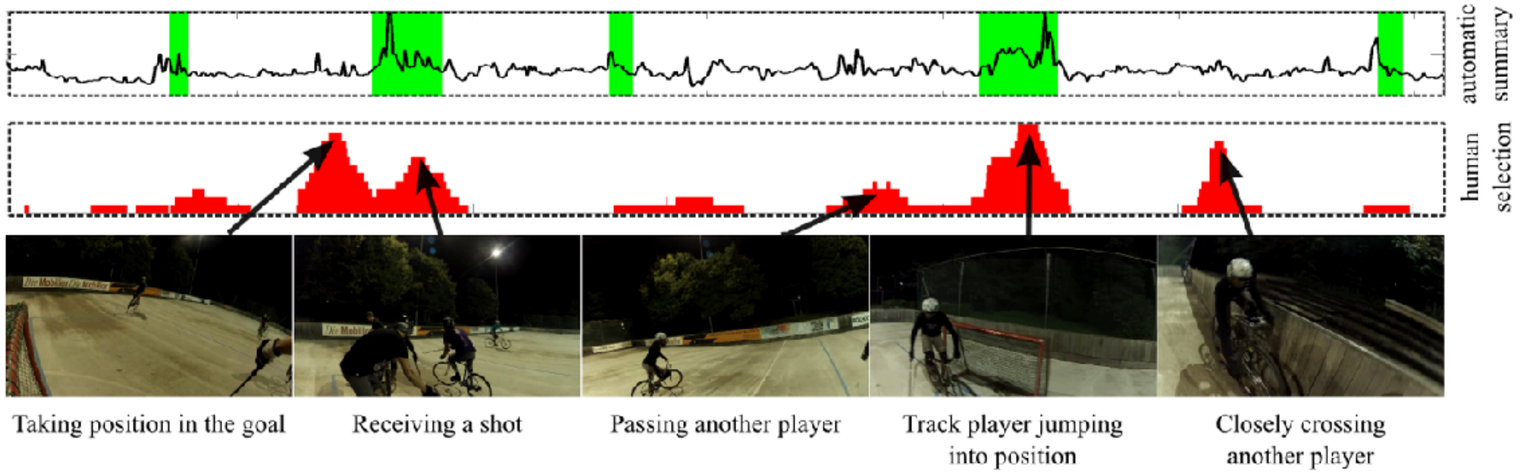


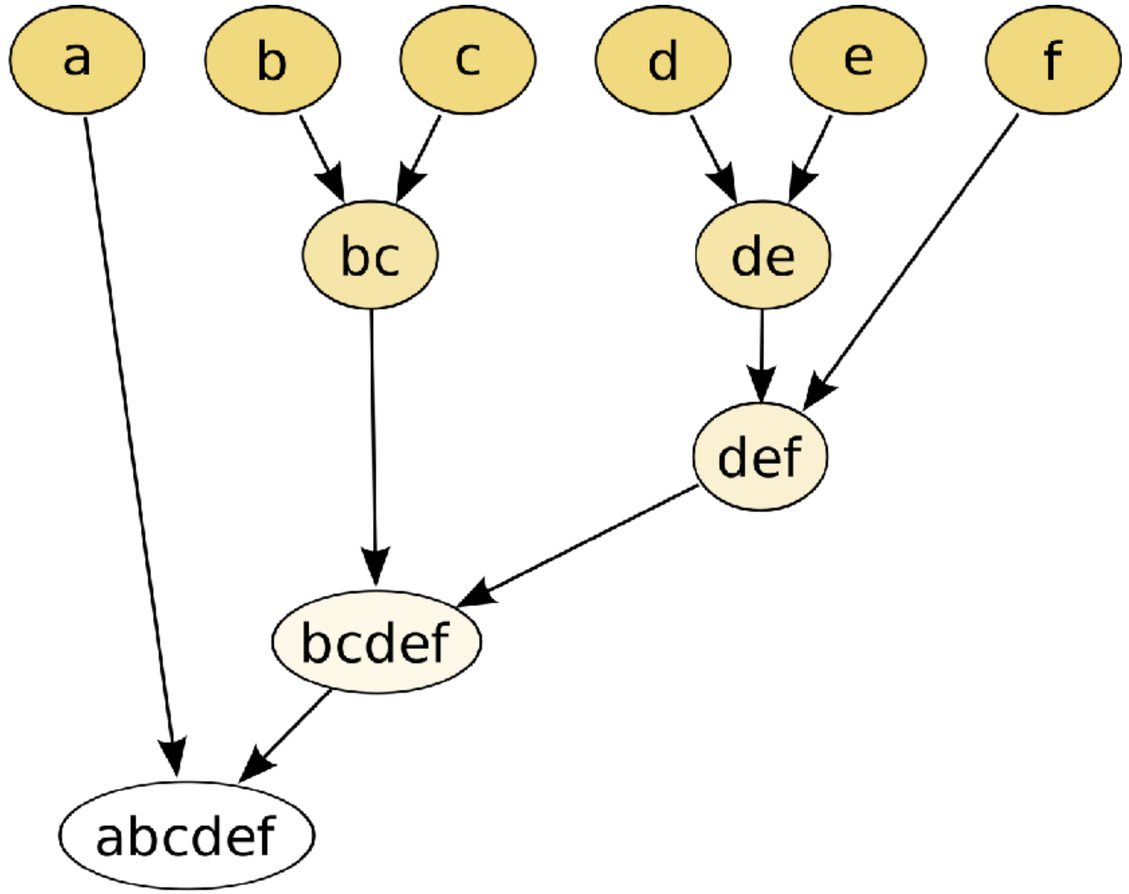
(Gigly et.al. , 2014) Creating Summaries from User Videos.

3. Hierarchical Clustering

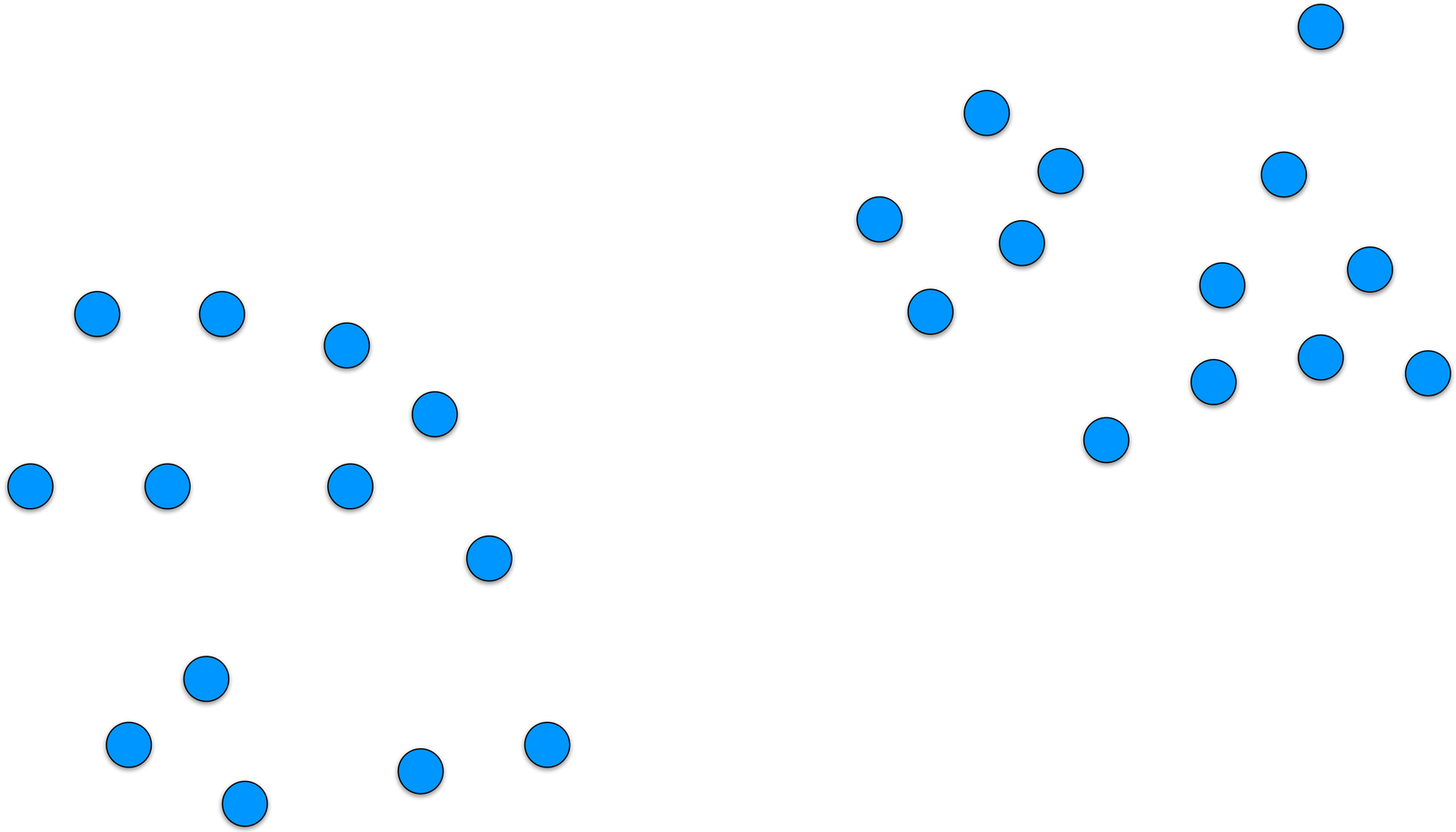
Hierarchical Clustering

General Idea:

- Find the closest two points and cluster them
- The clustered points are considered as a new point
- Repeat until the distance of the closest two points is too large



Algorithm



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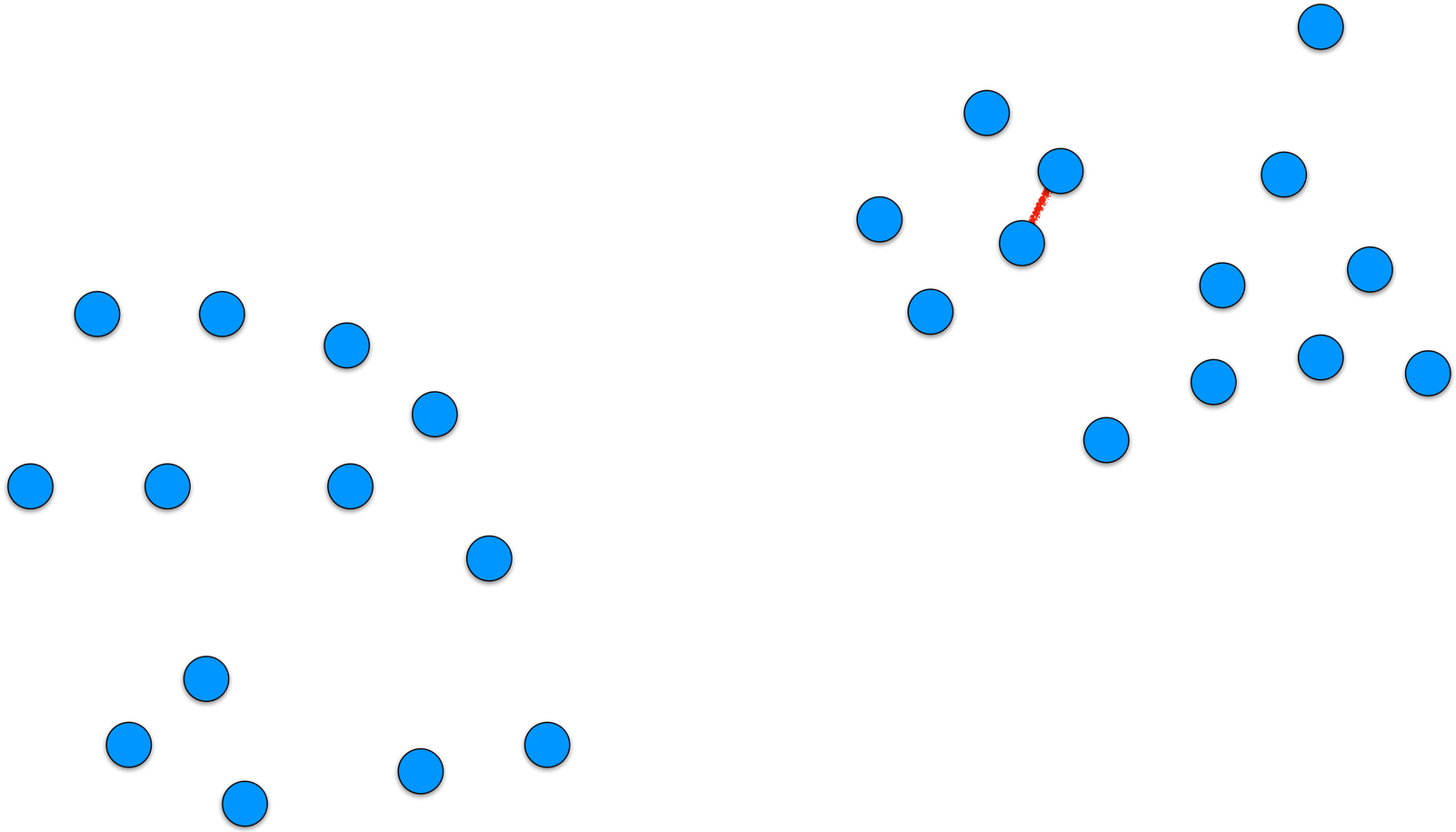

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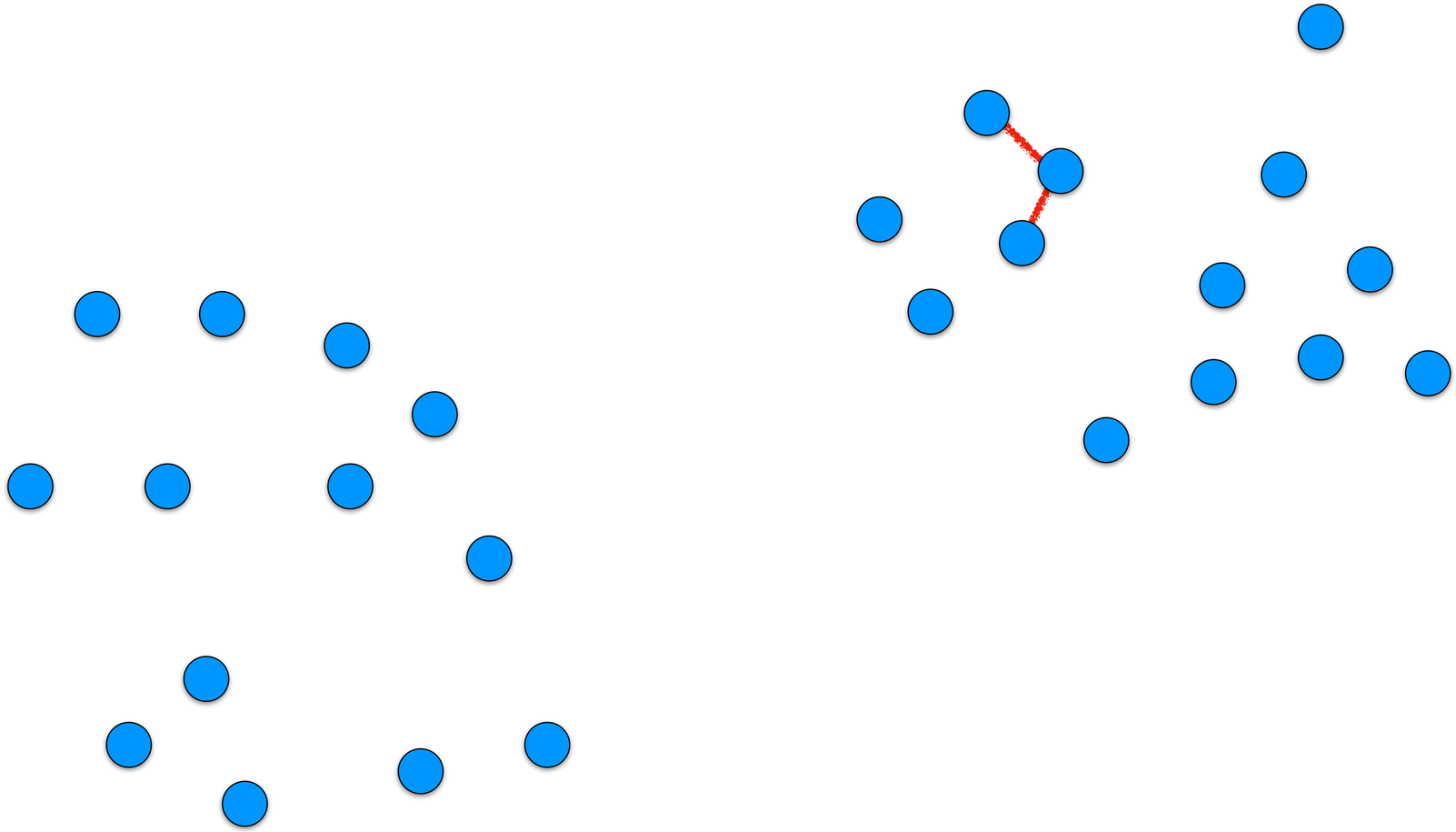

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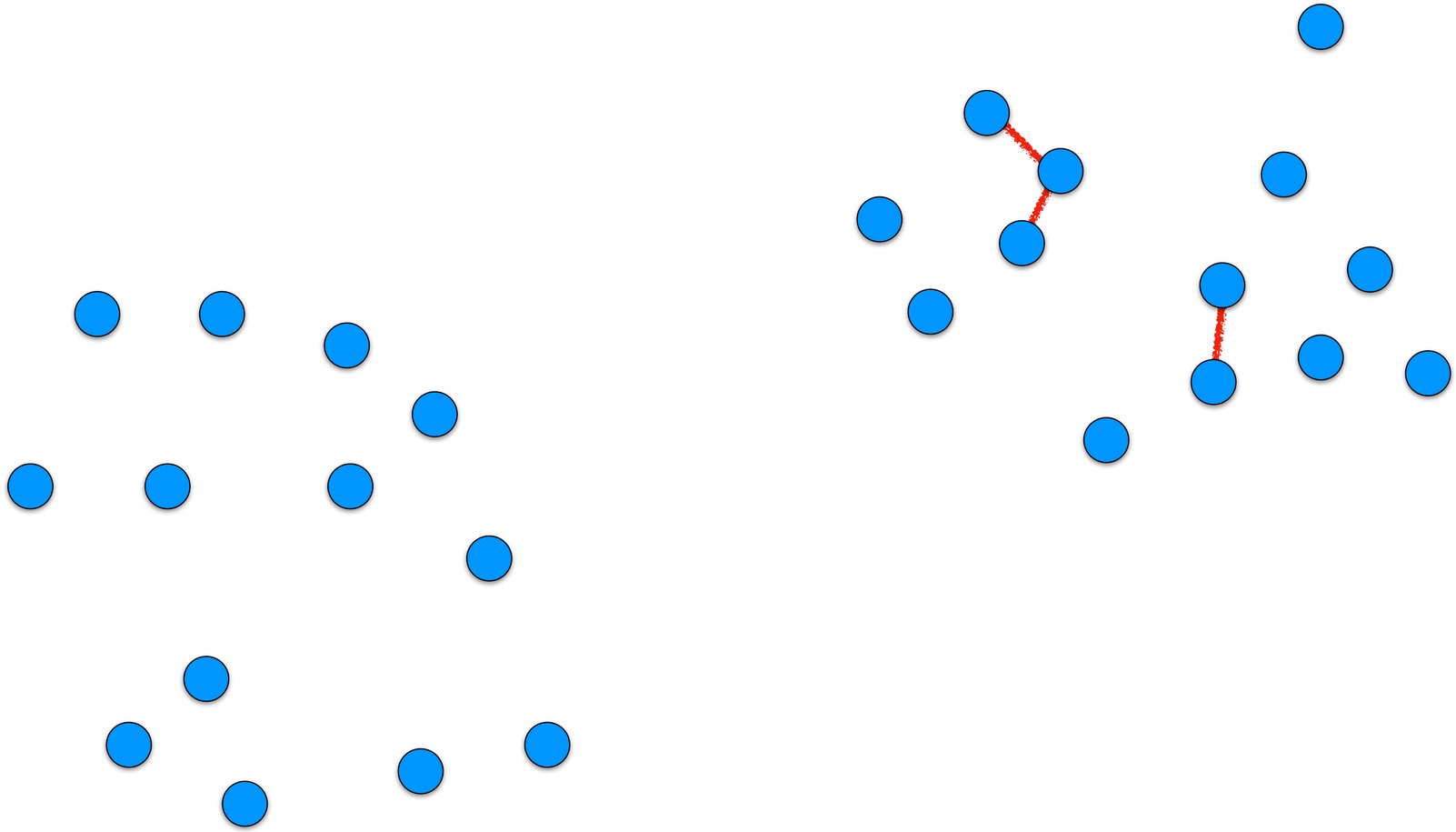

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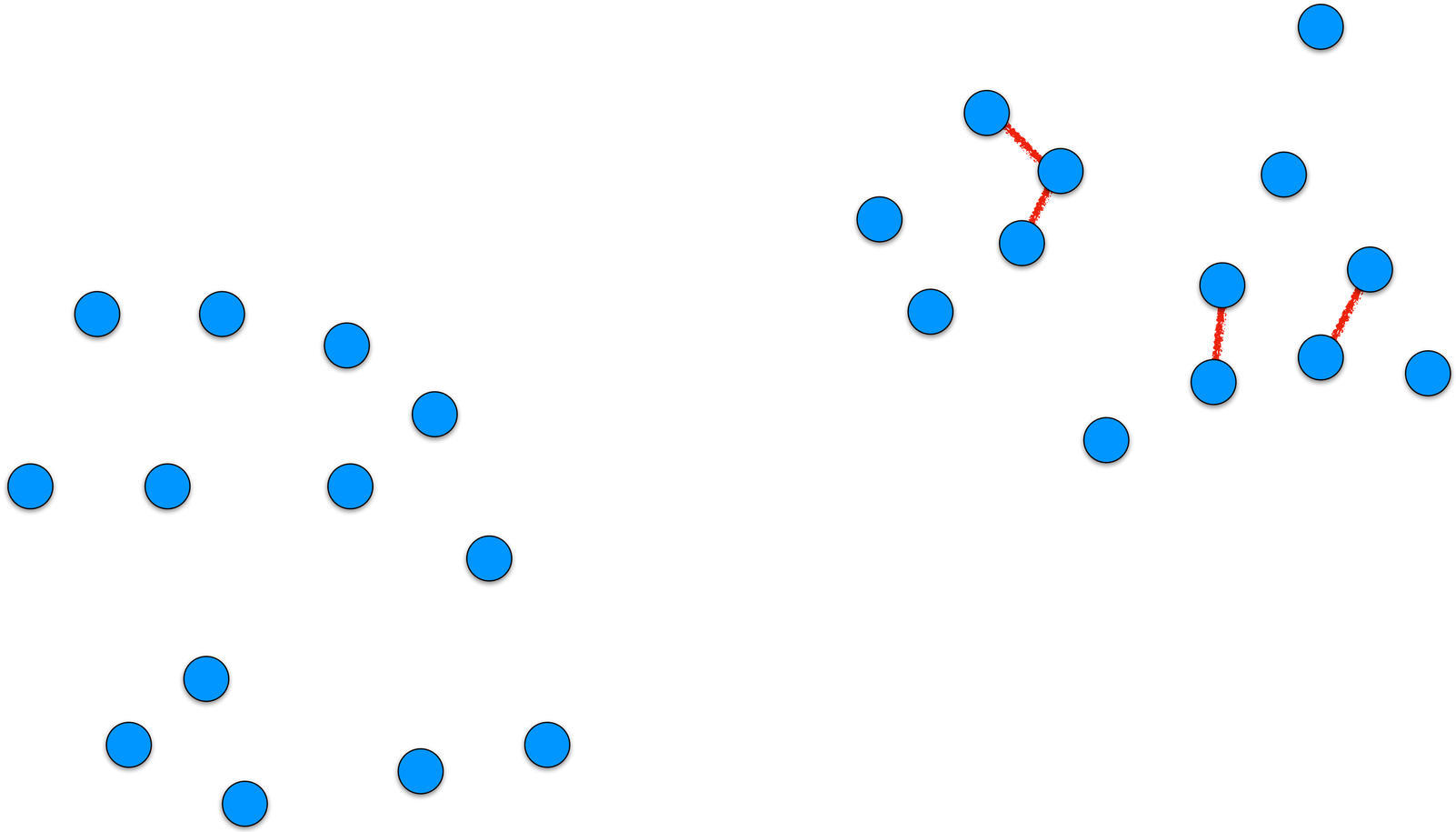

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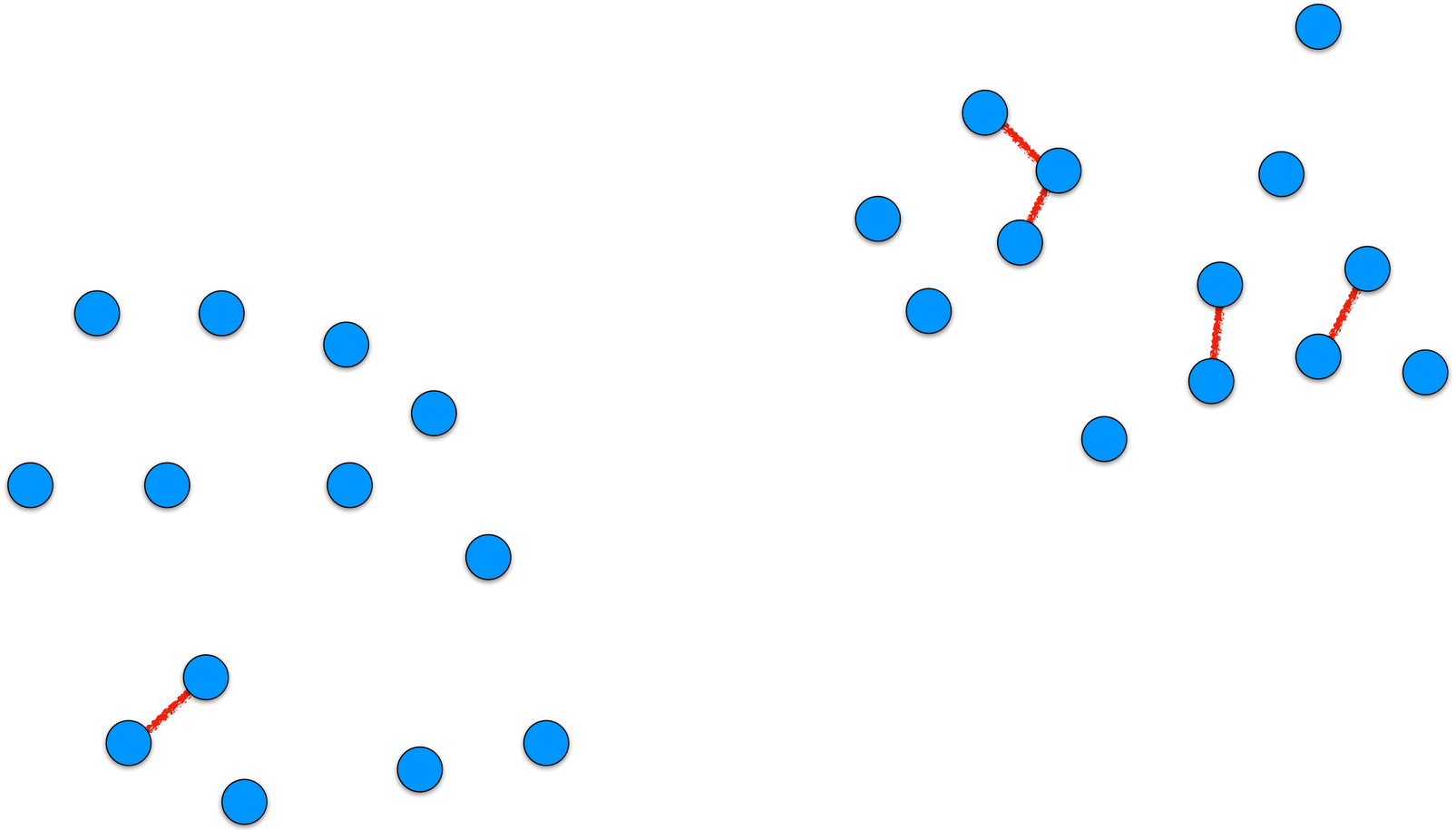

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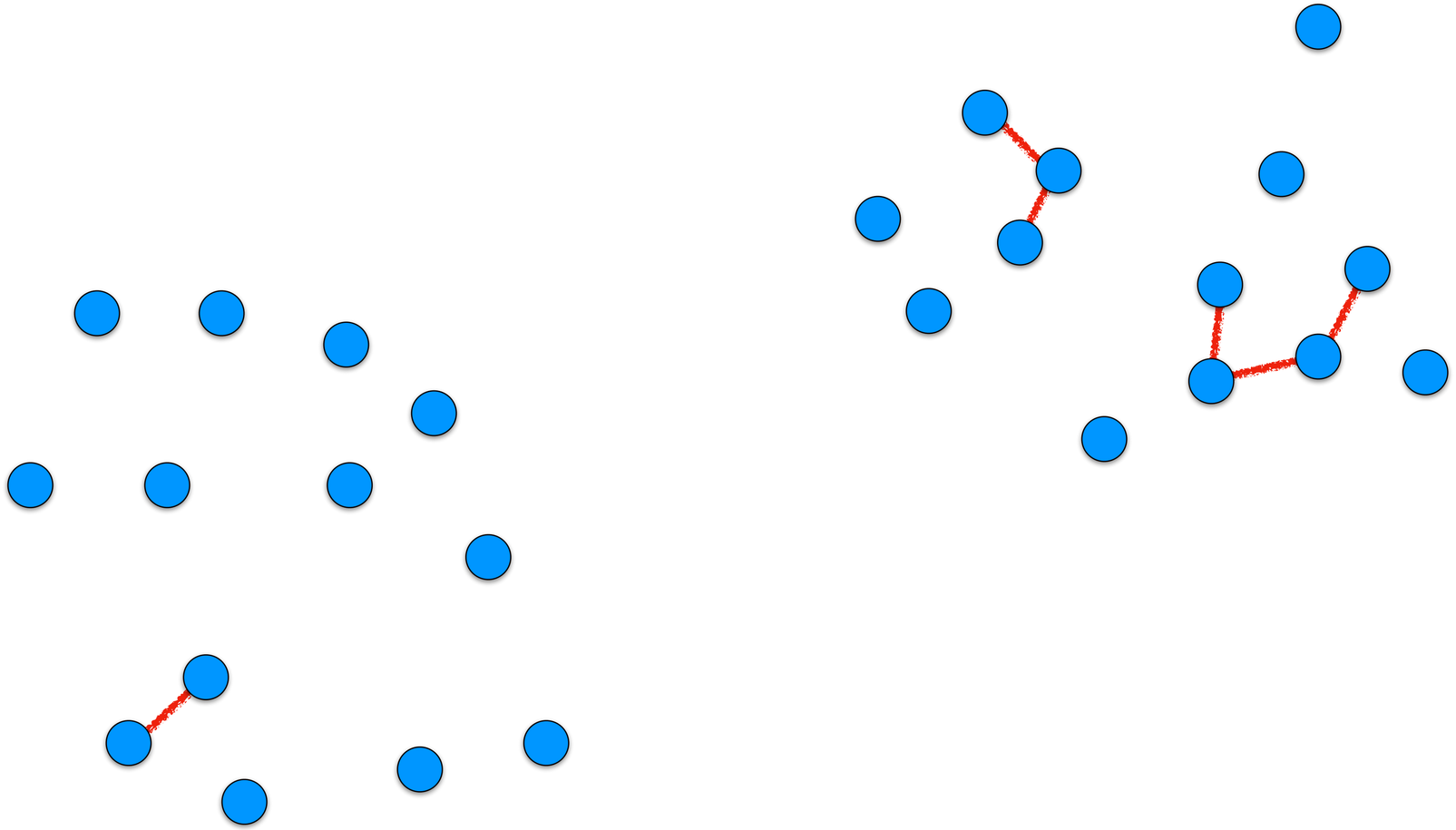

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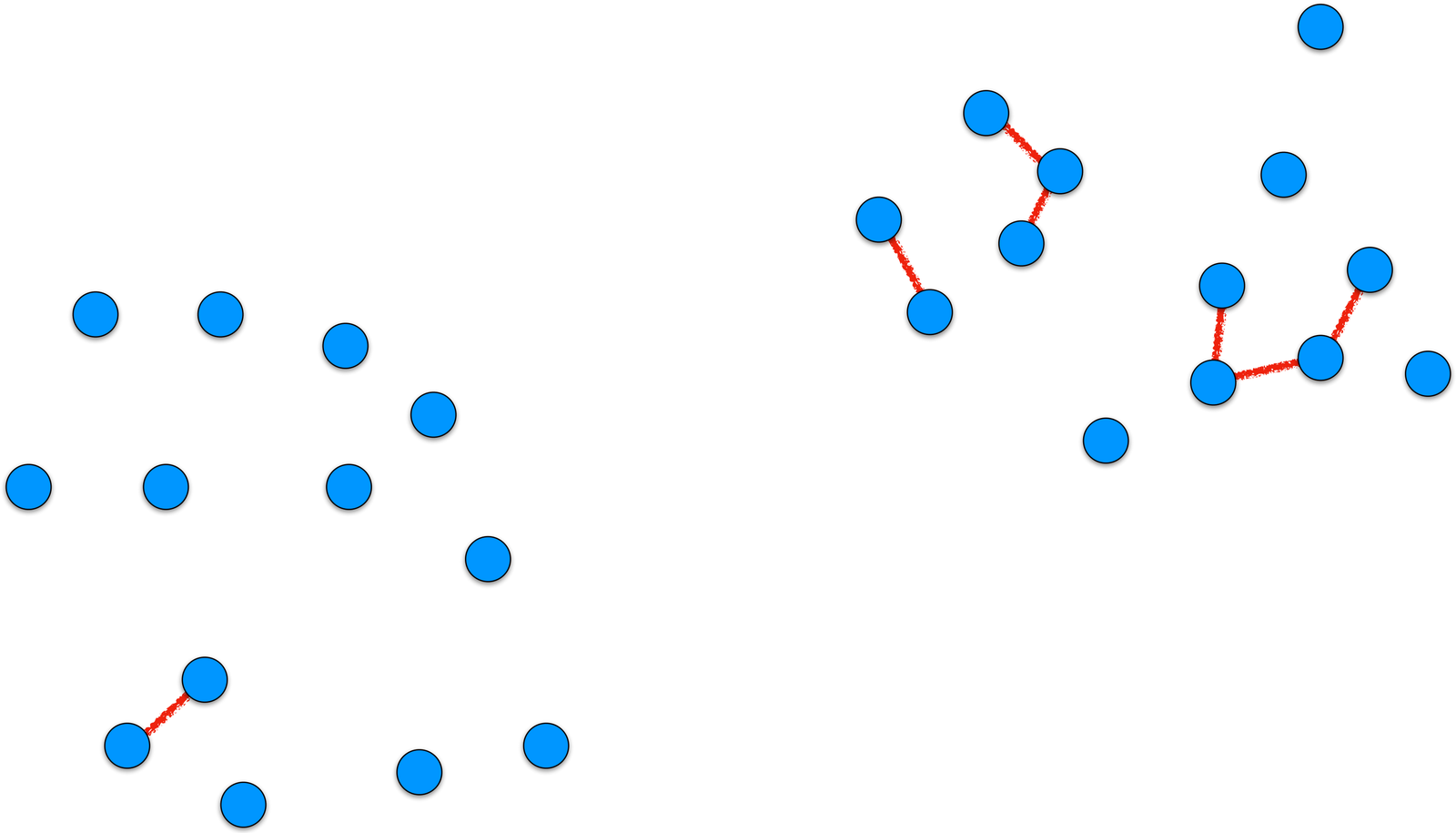

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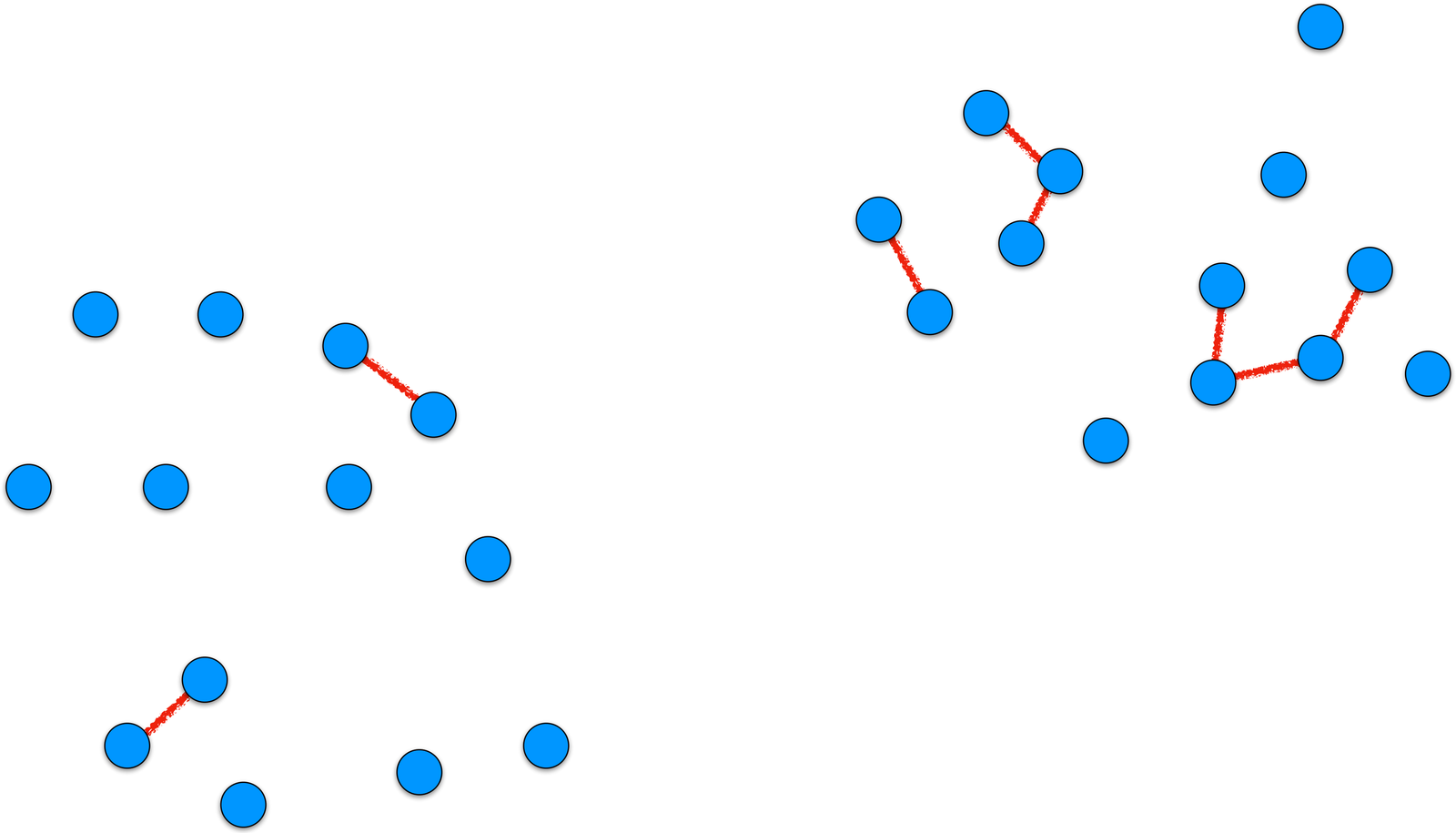

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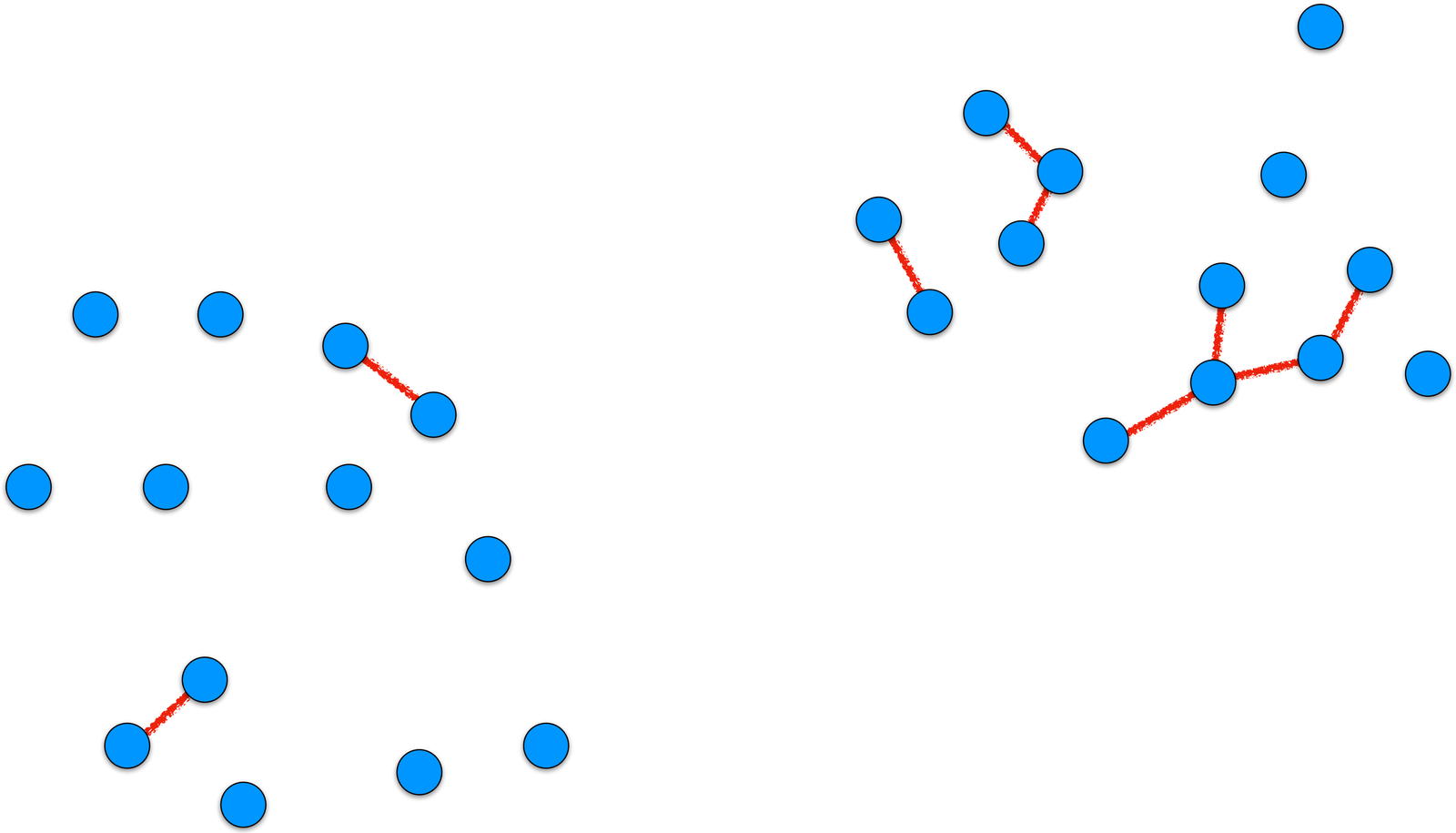

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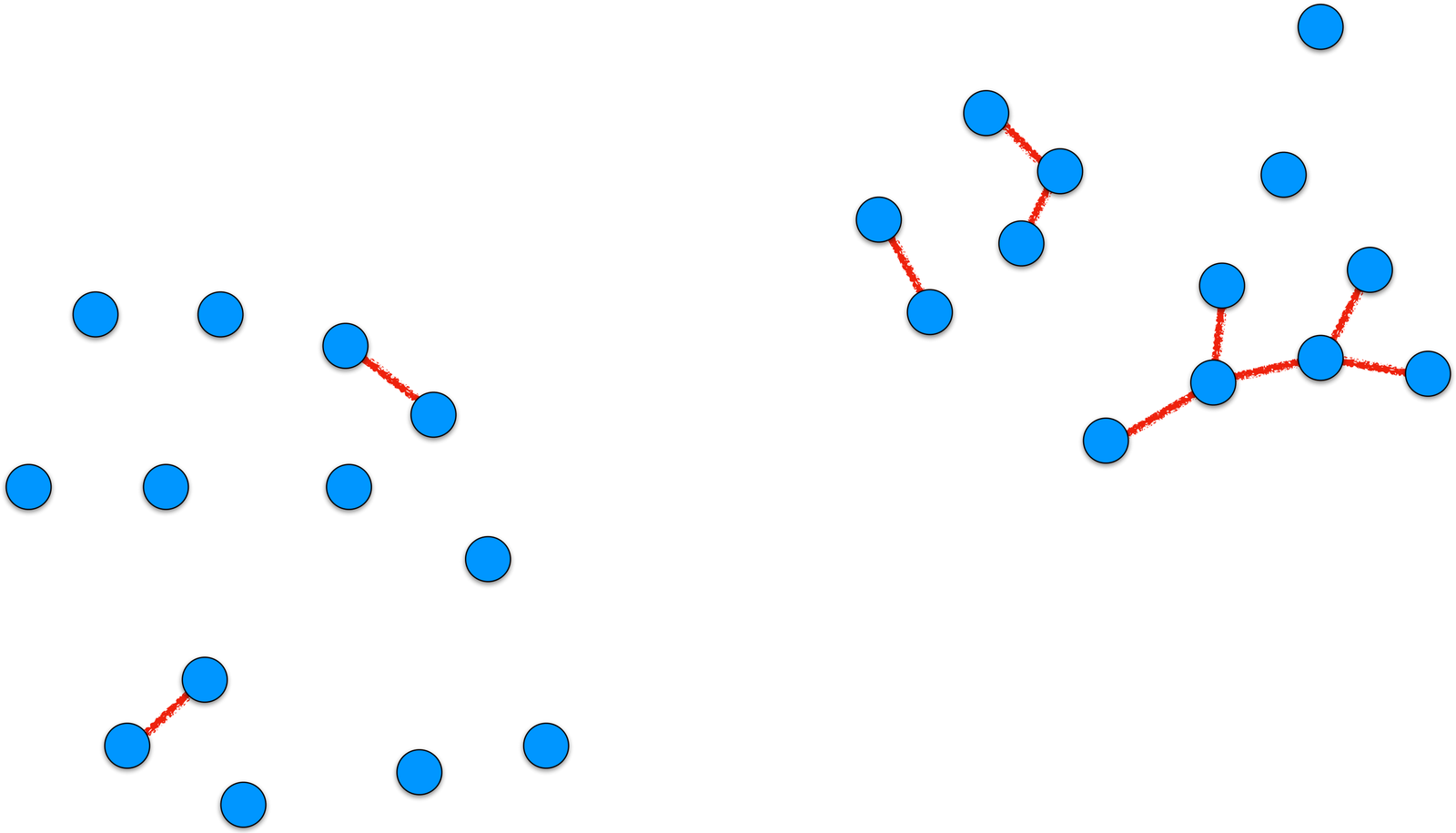

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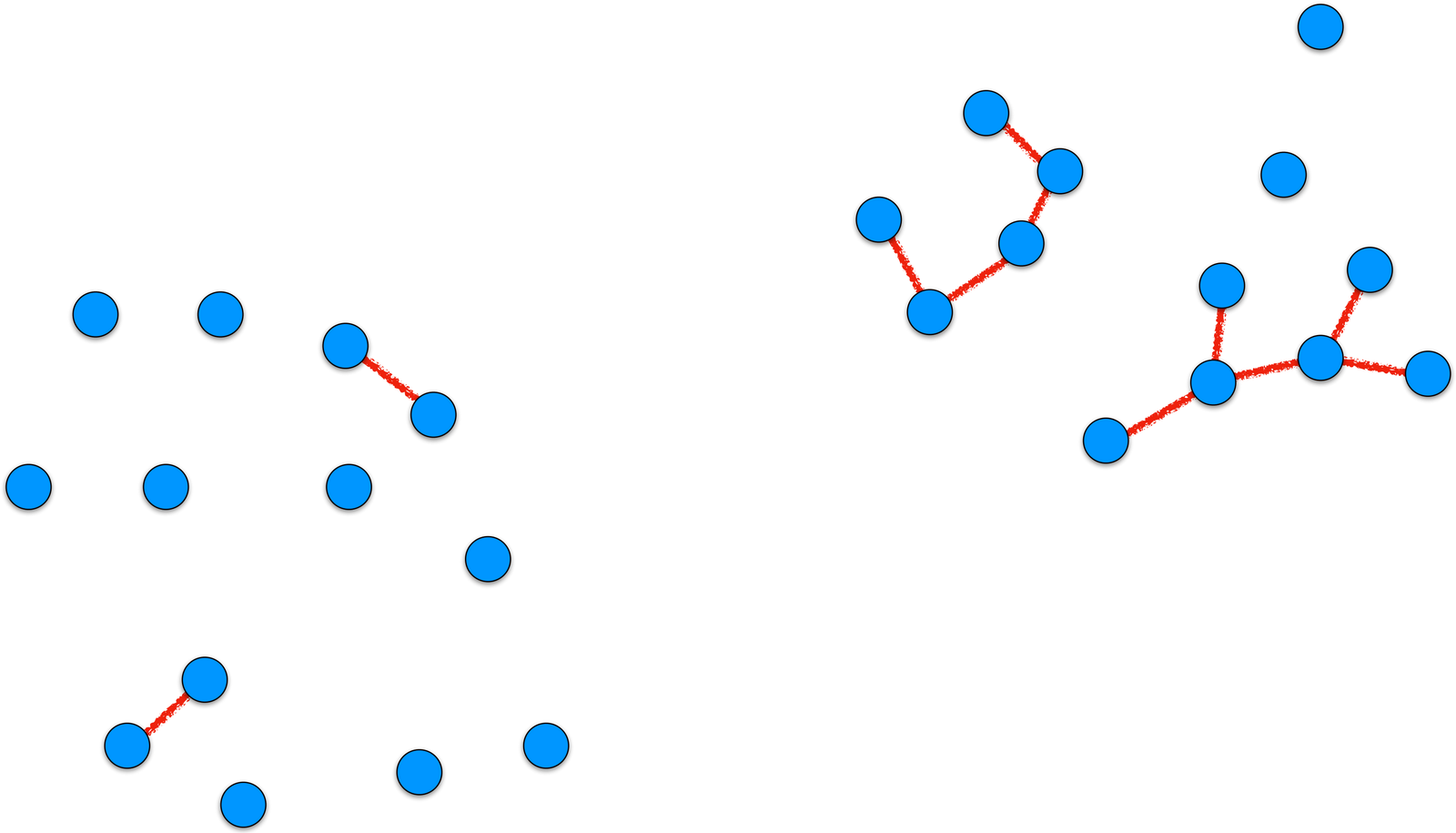

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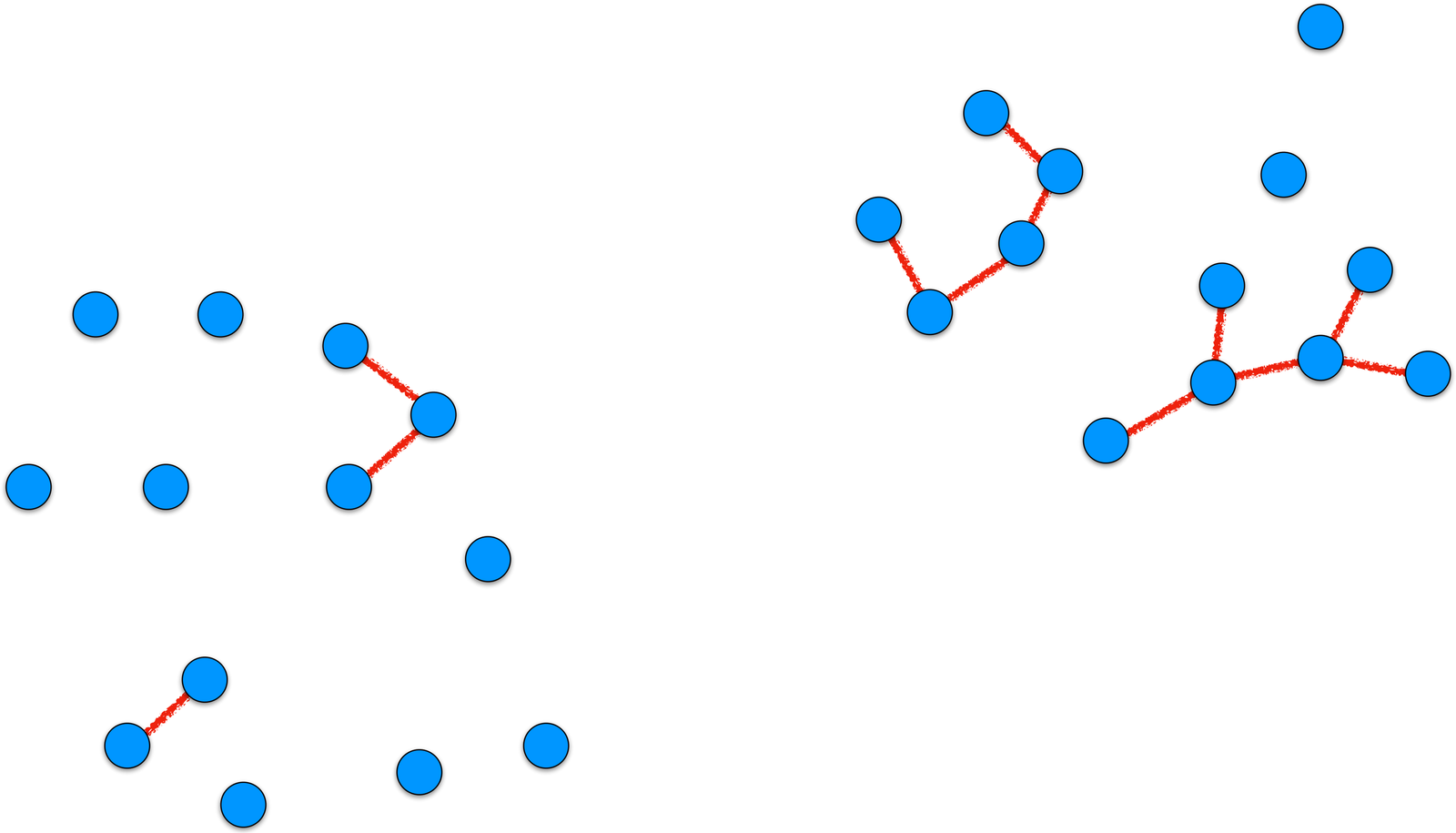

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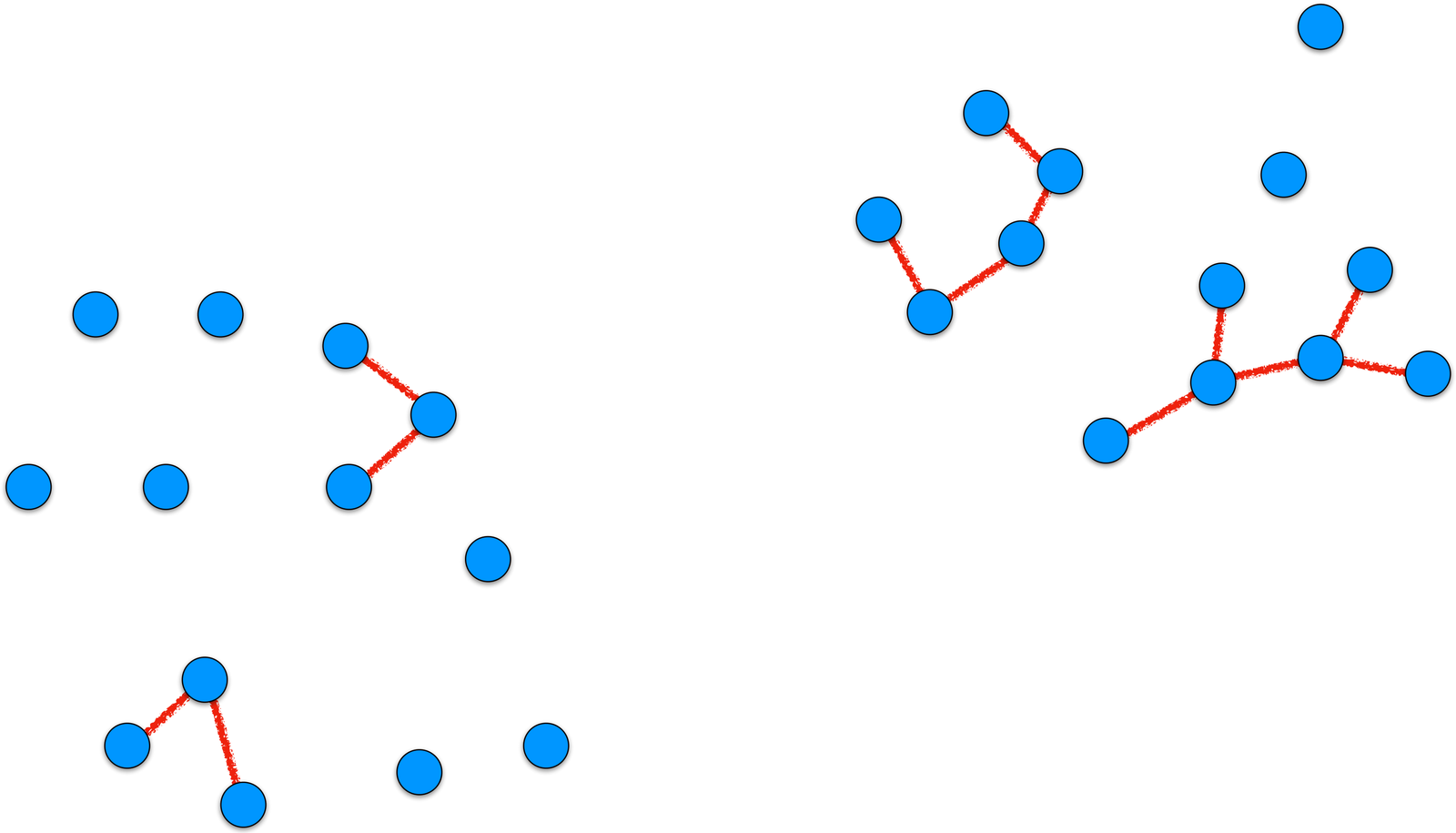

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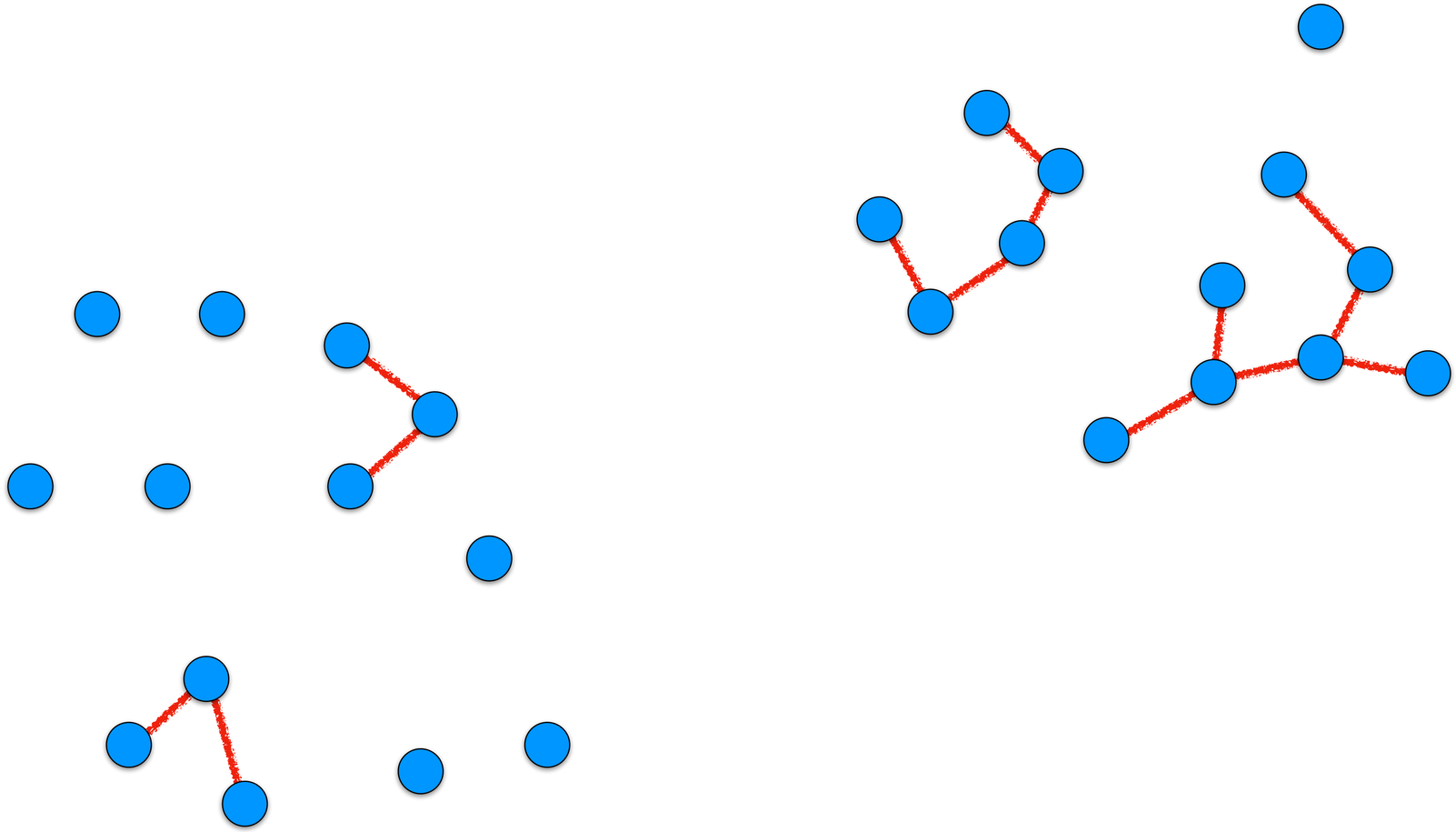

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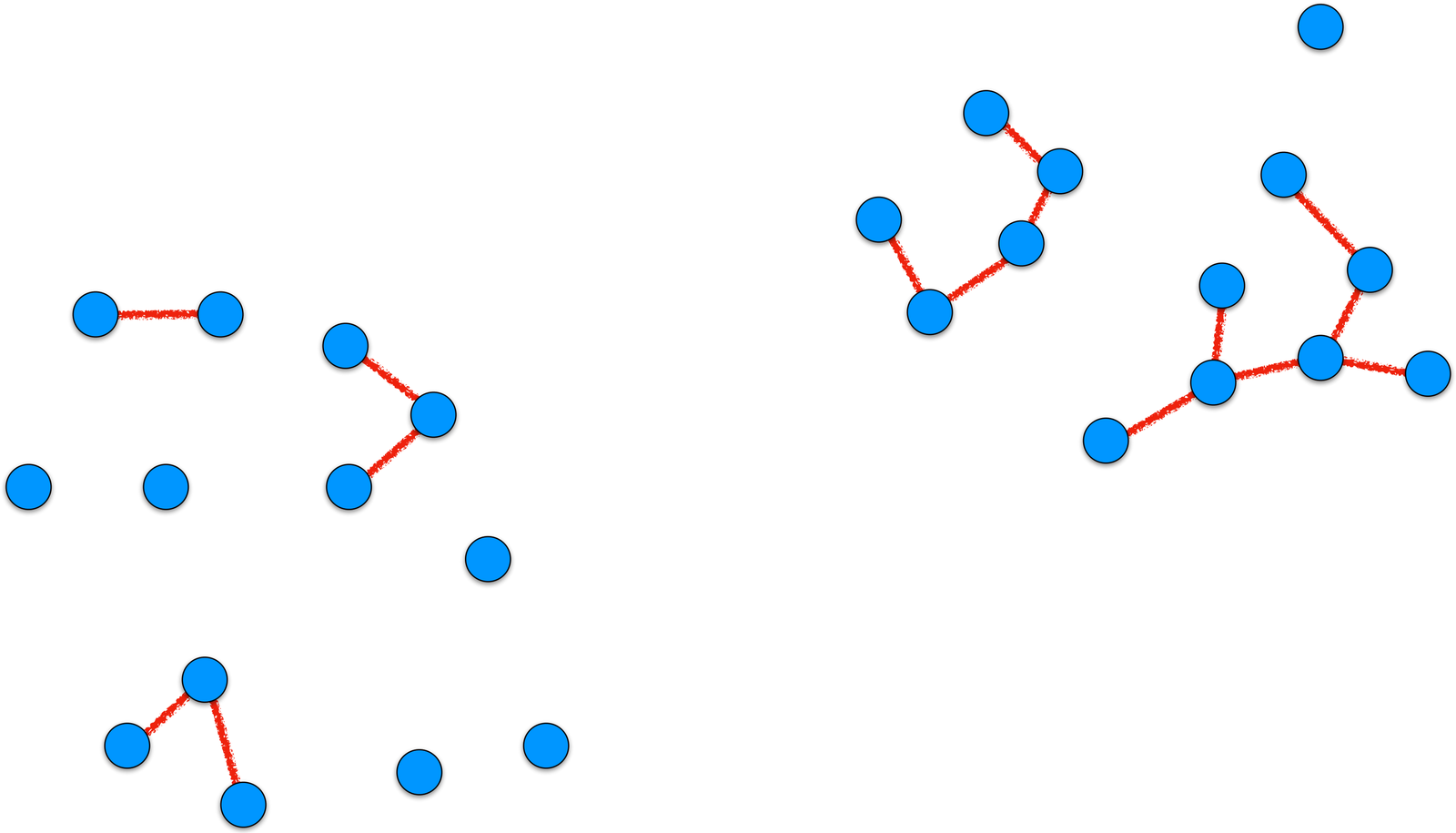

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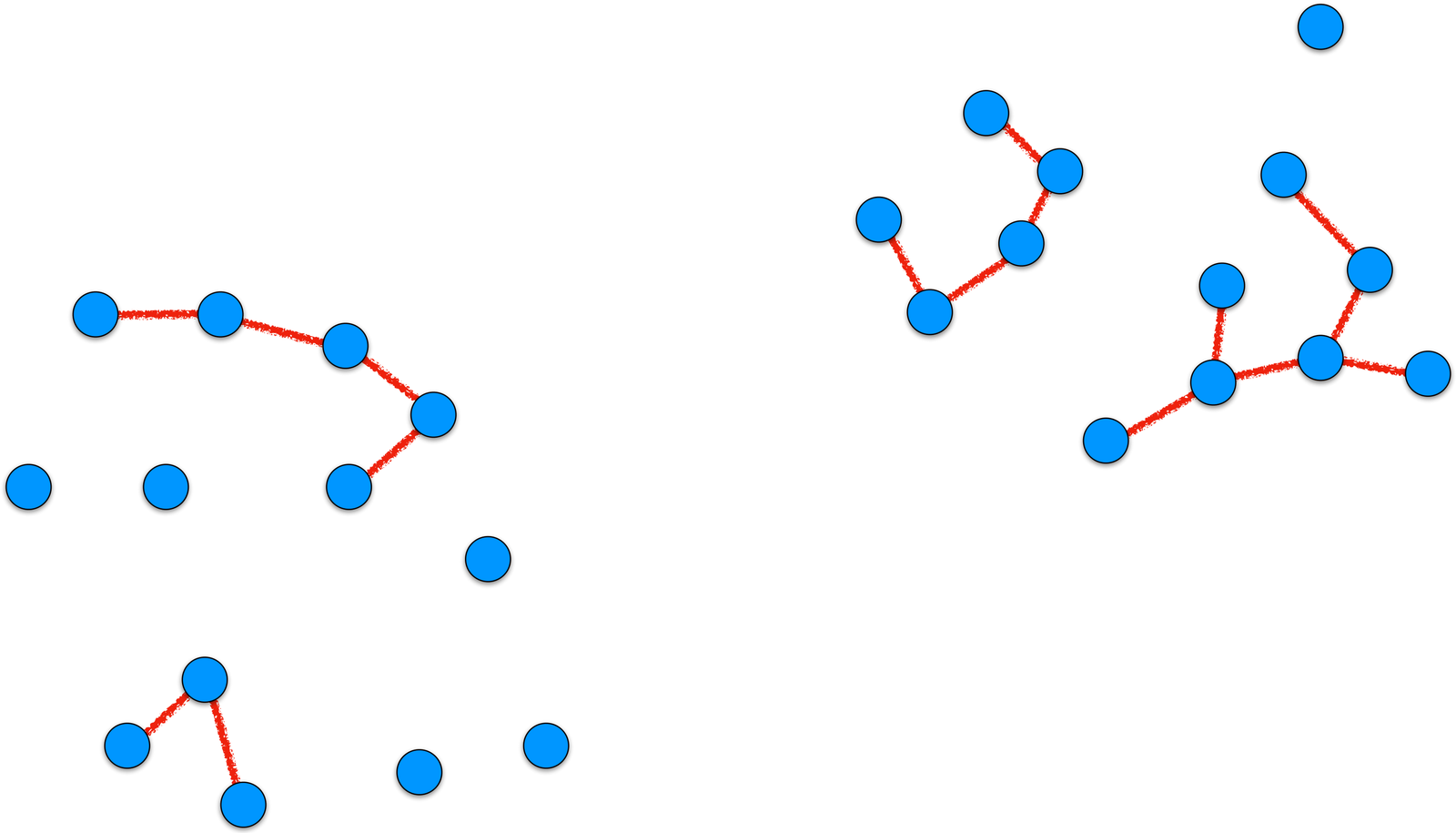

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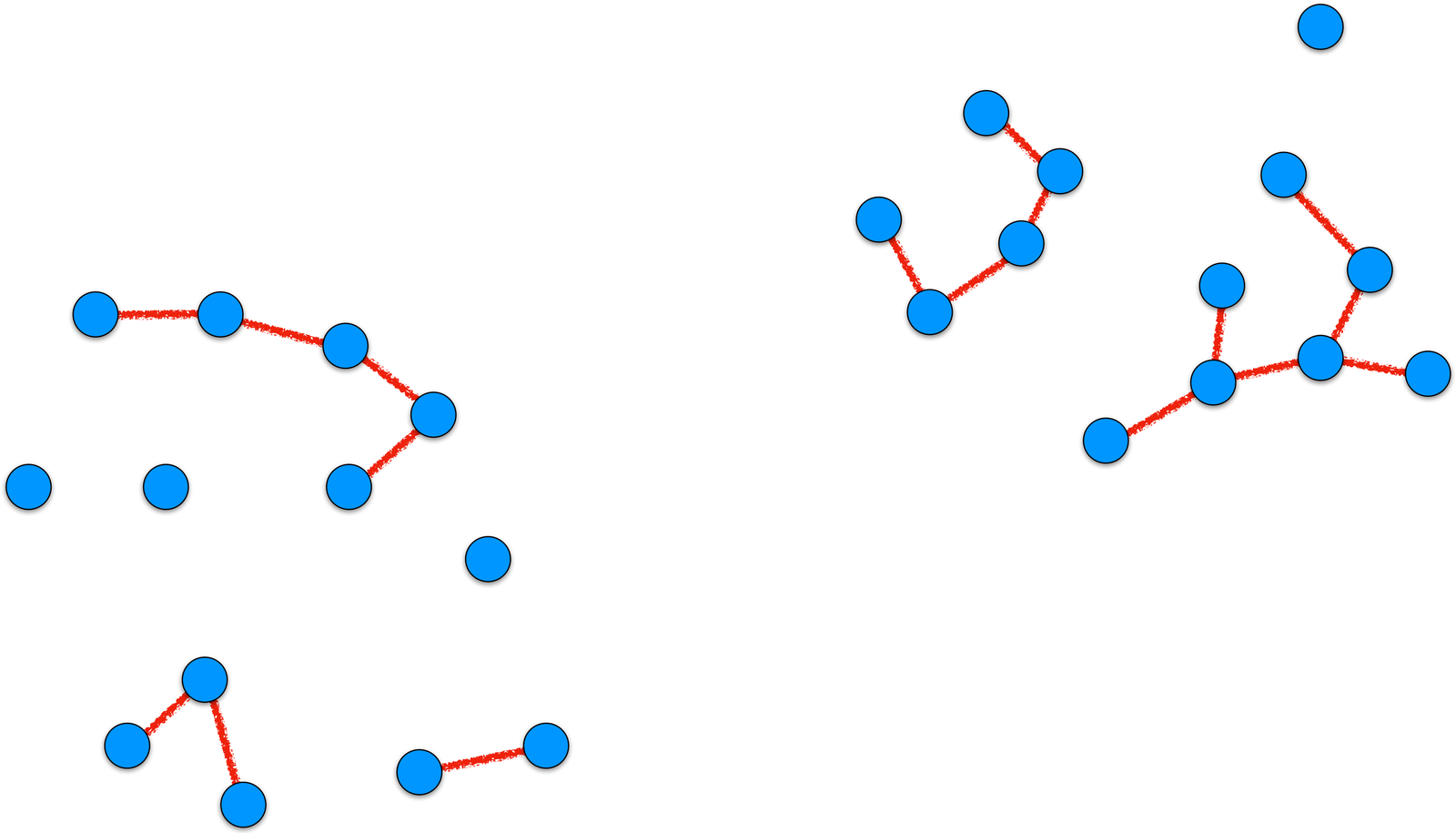

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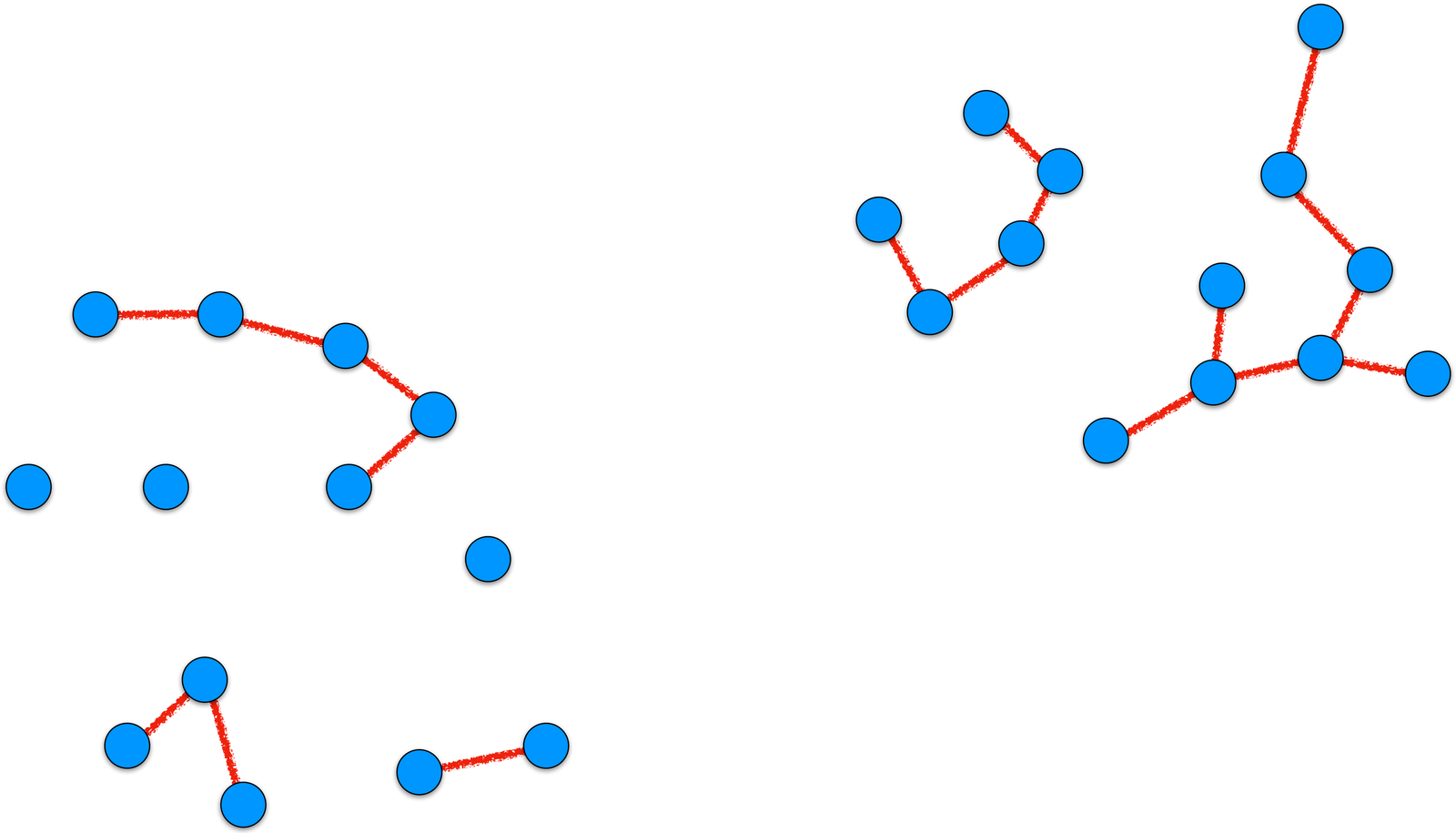

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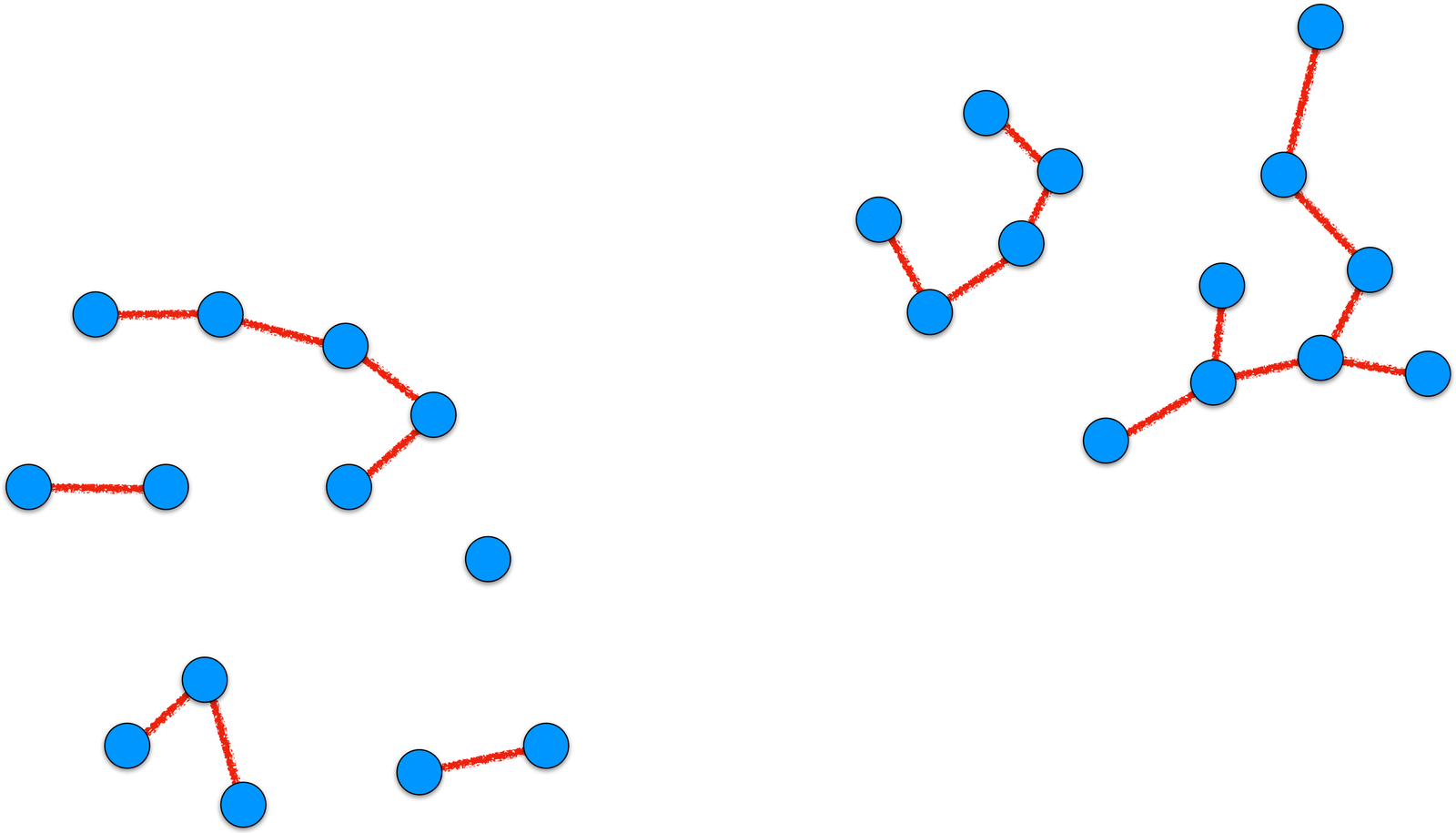

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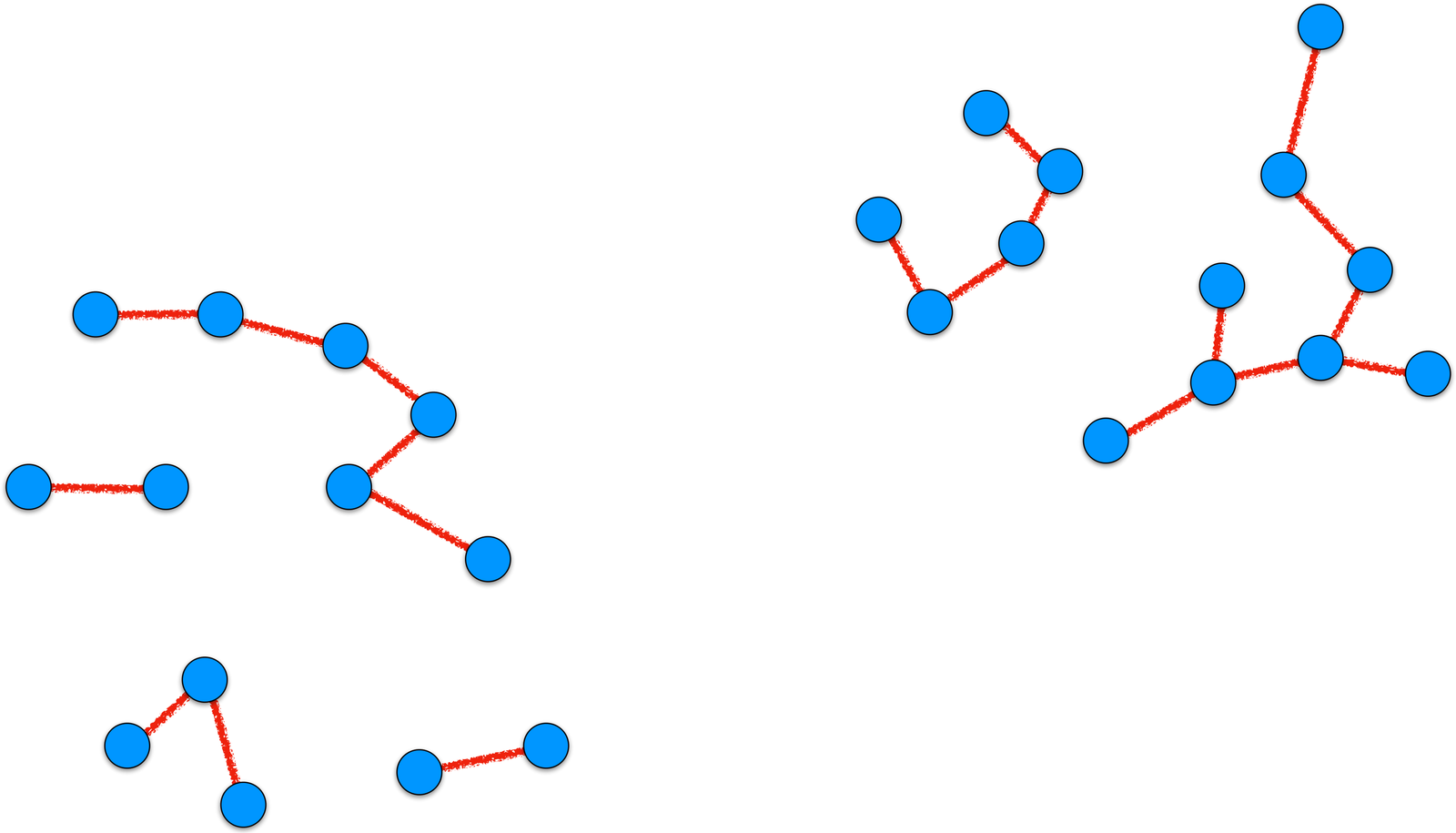

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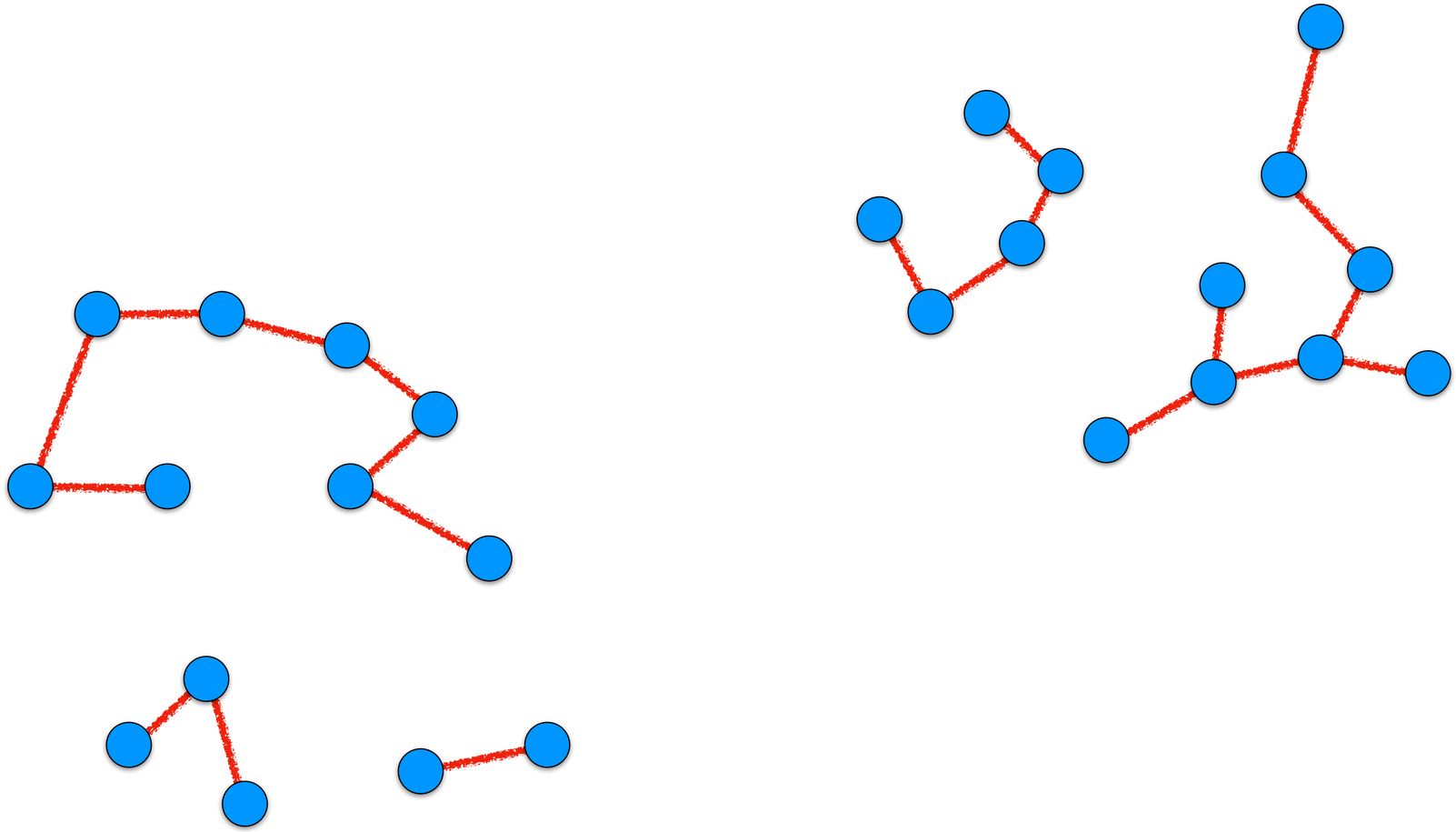

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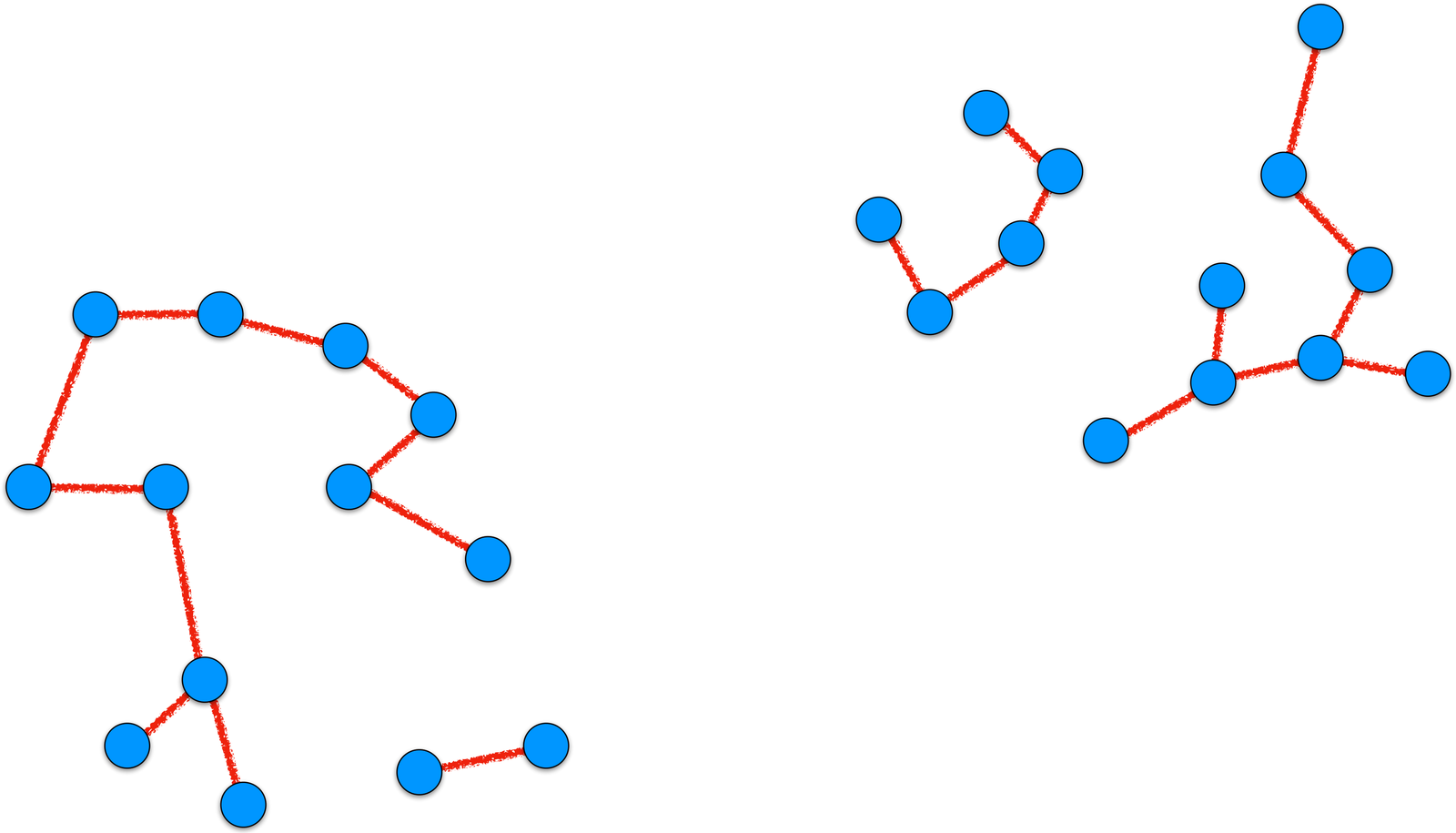

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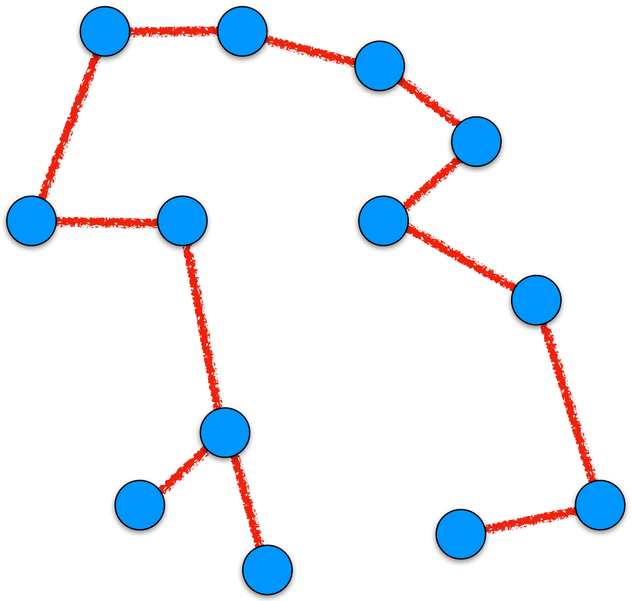
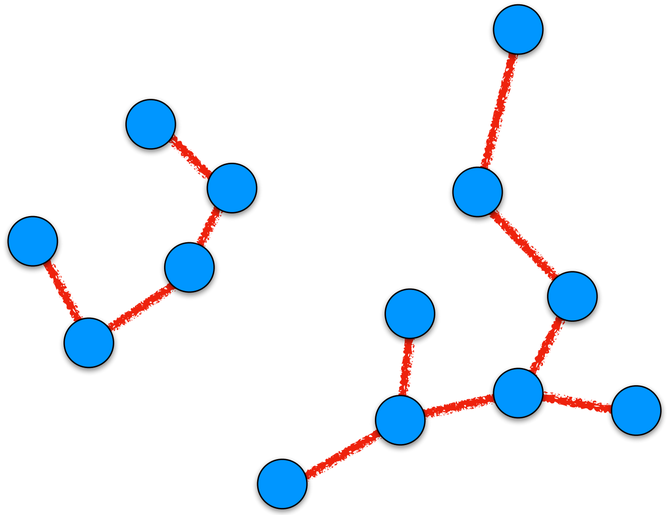
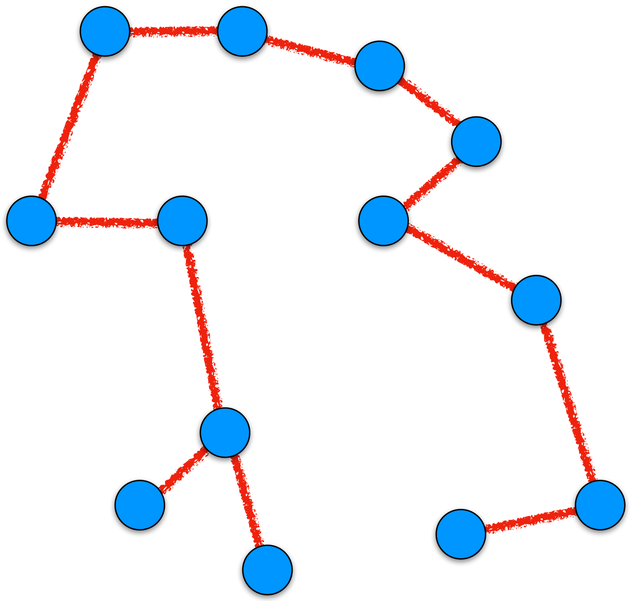
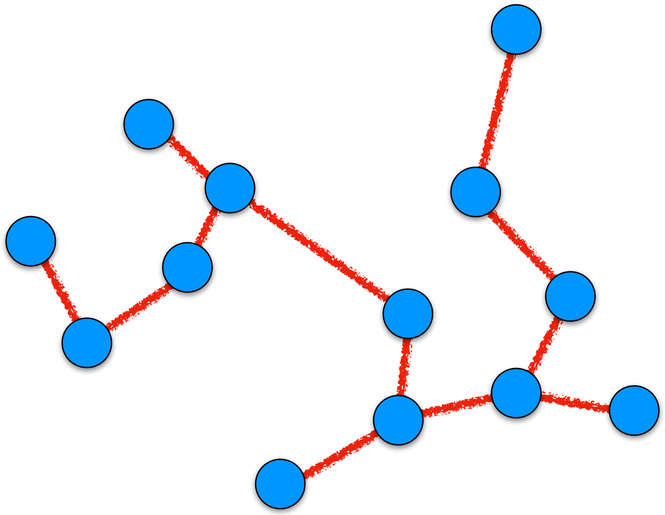


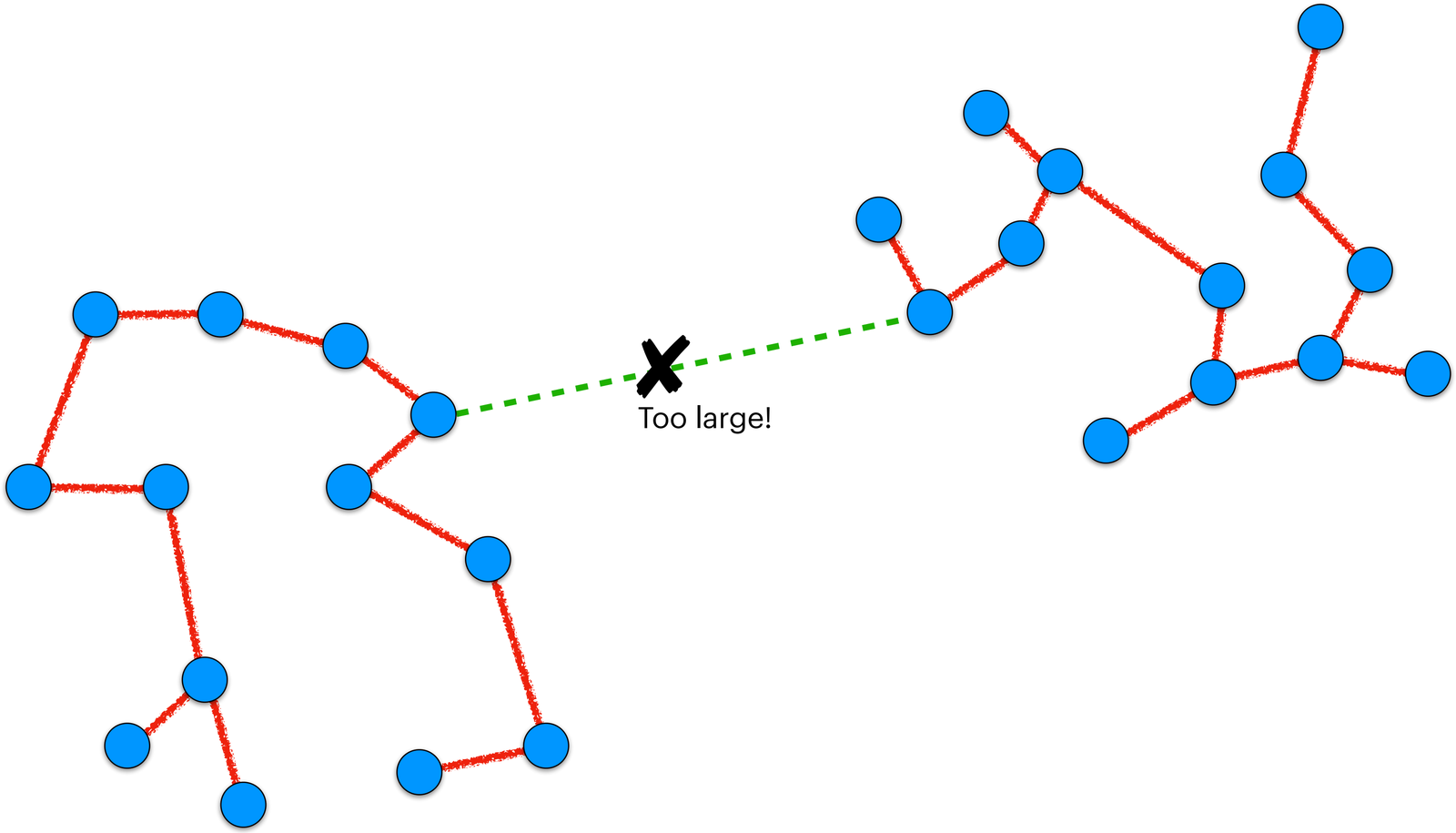


Algorithm

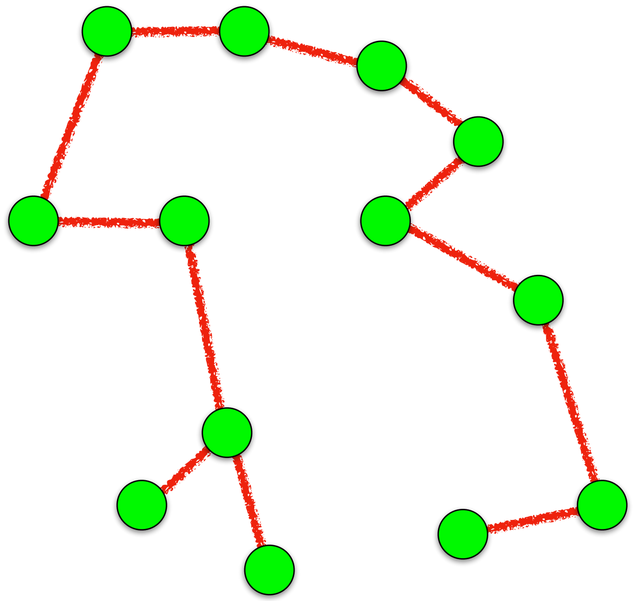


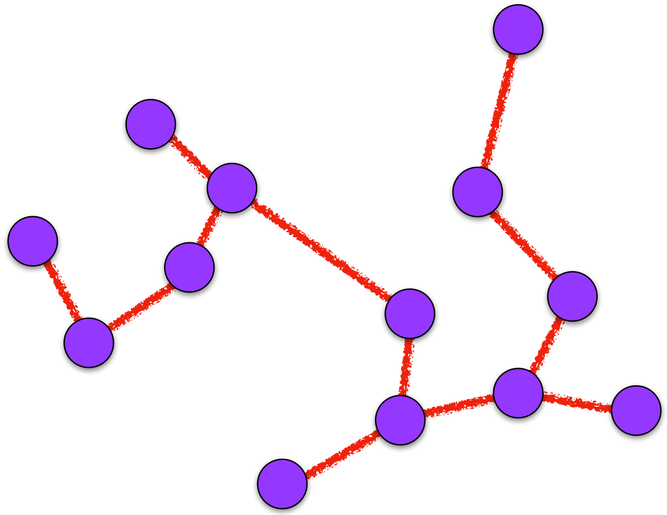


Algorithm

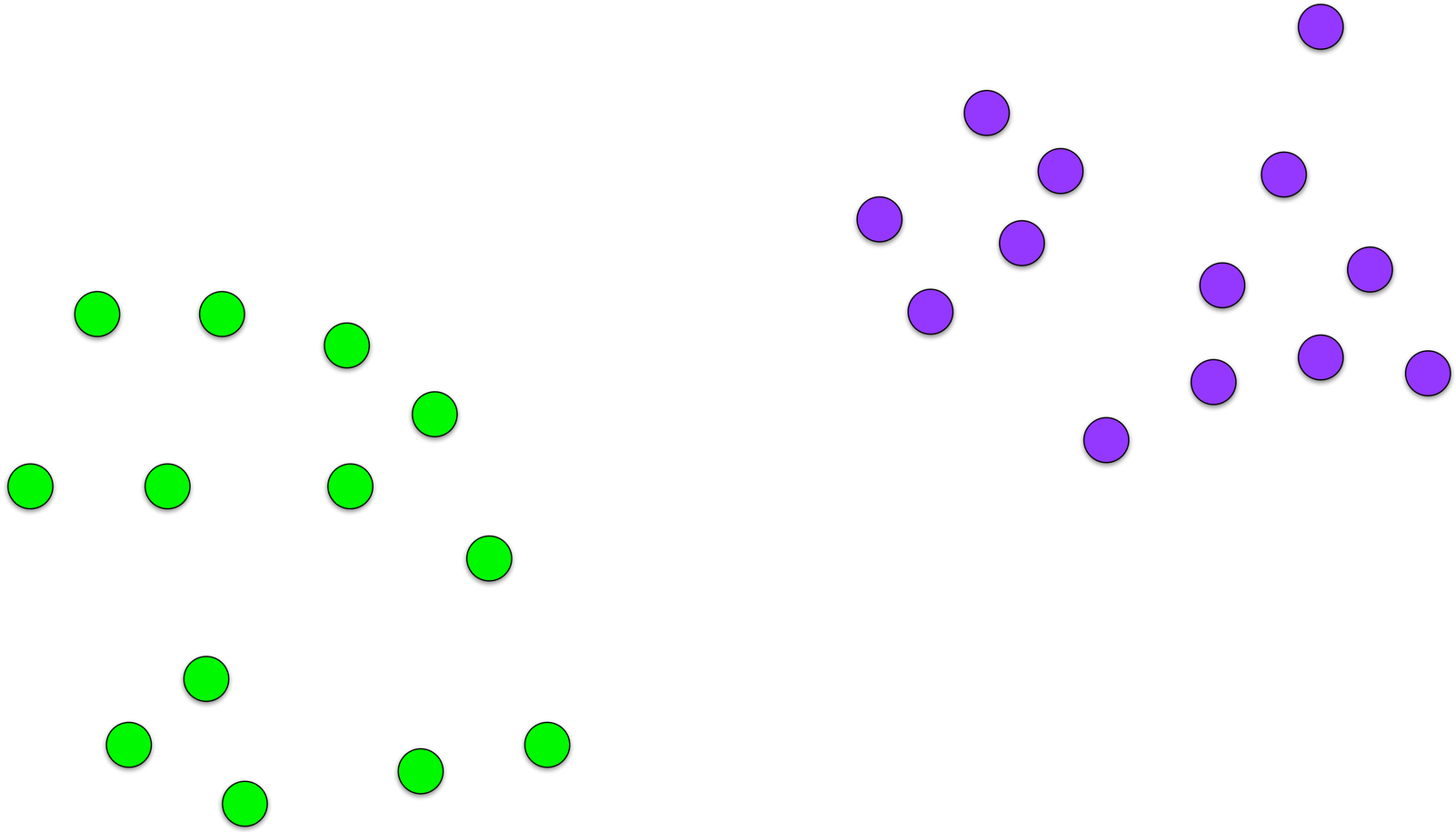


Algorithm

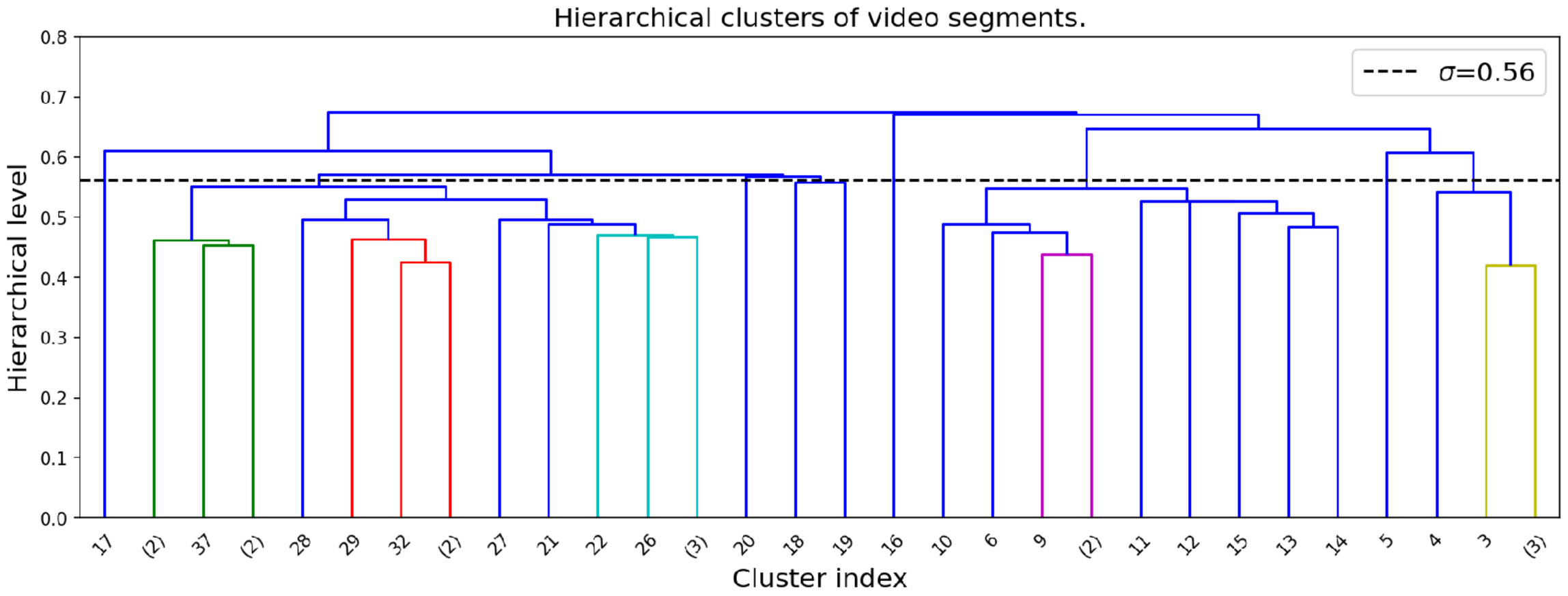




Algorithm



Algorithm: Dendogram



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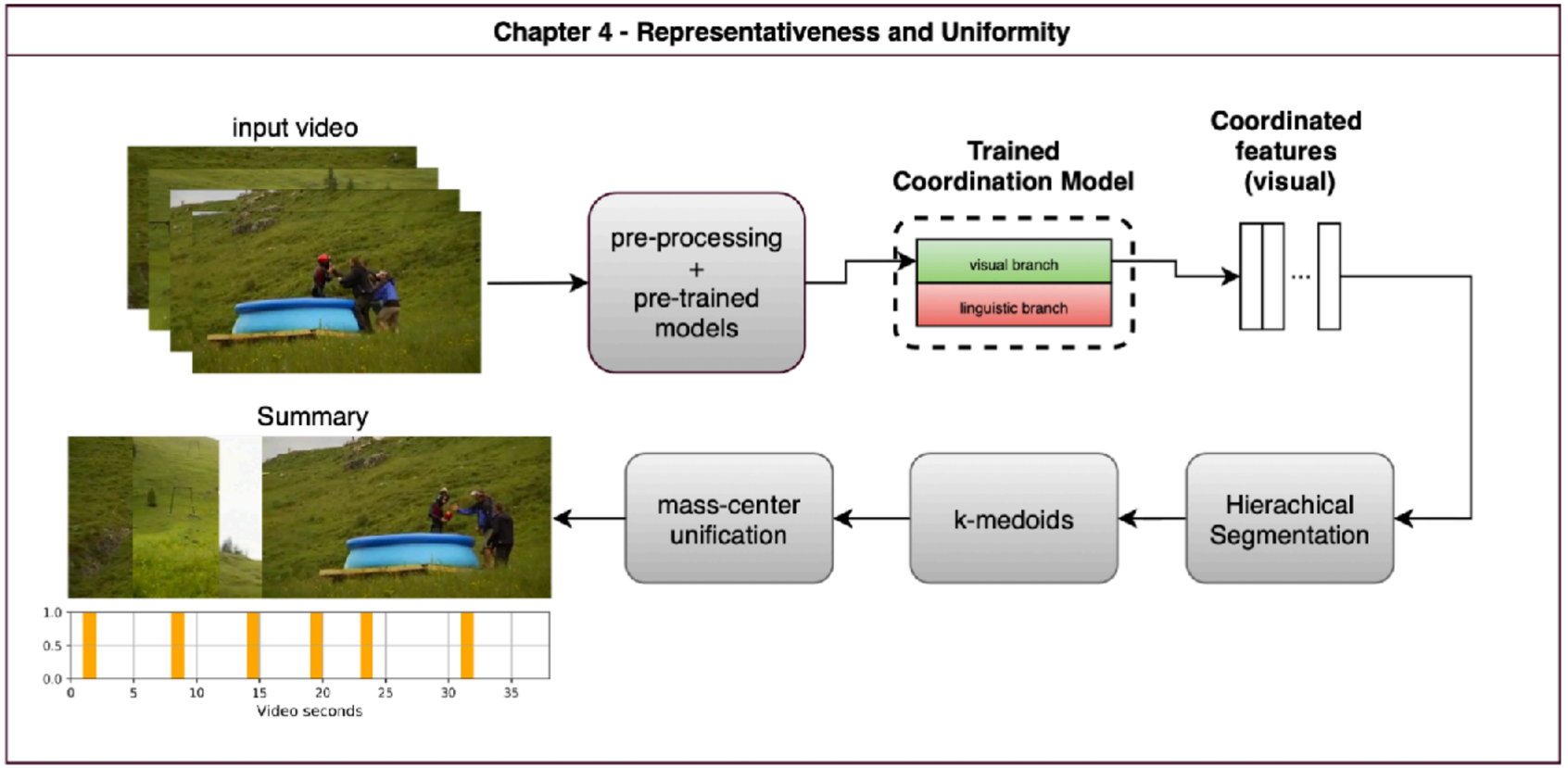
Hierarchical Clustering

Single Linkage Clustering with Scikit-learn

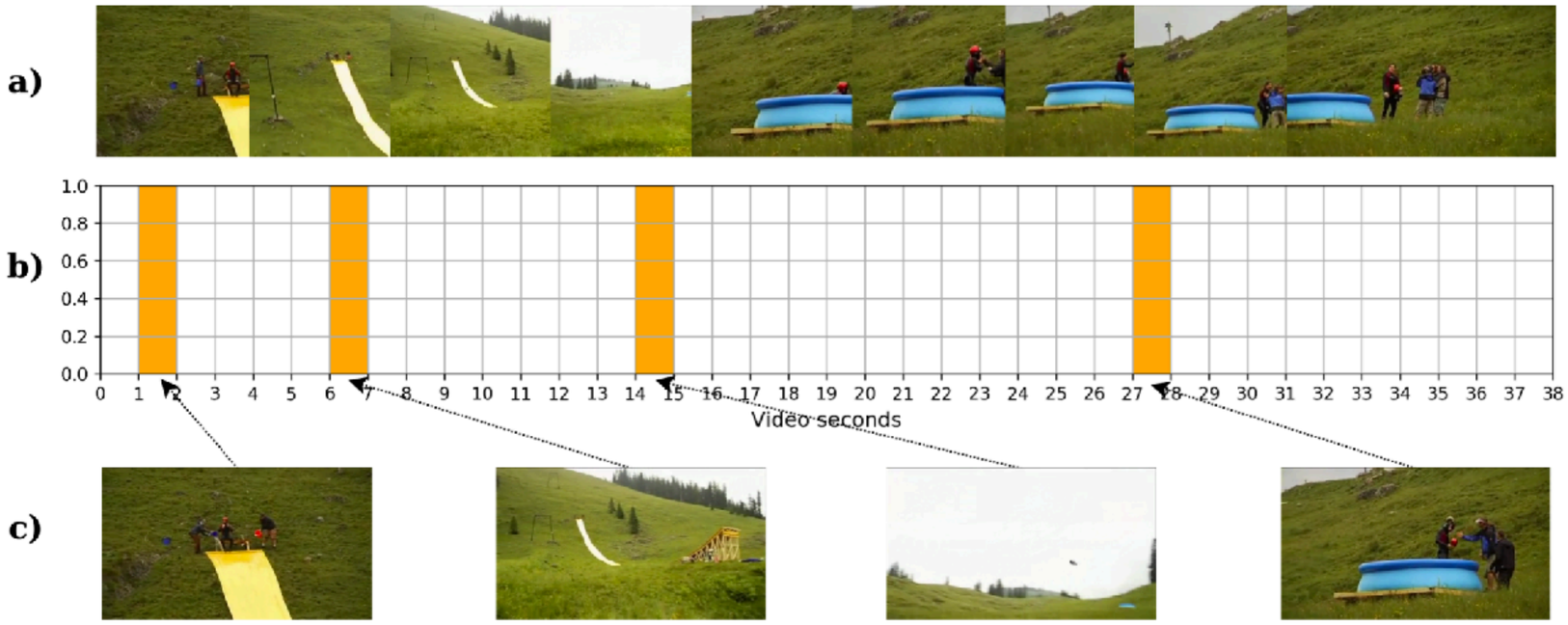
4. Study Case

Video Summarization

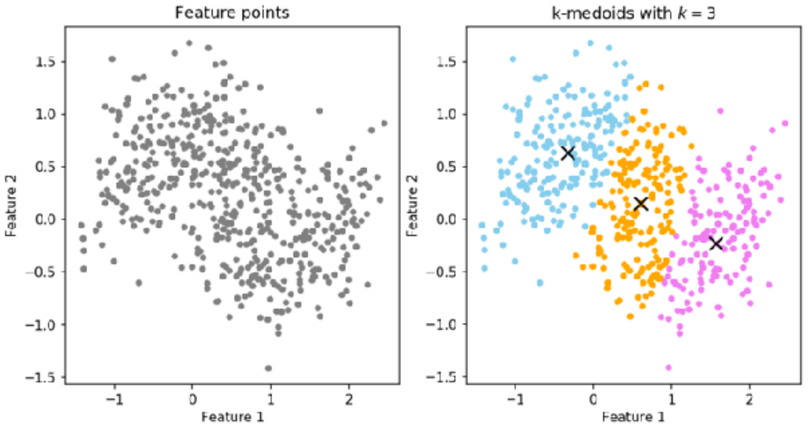


(Atencio et. al. , 2020) Query-based video summarization using machine learning and coordinated representations

Video Summarization



$$F(S) = \sum_{x \epsilon X} min_{s \epsilon S} \|x - S\|_2^2$$

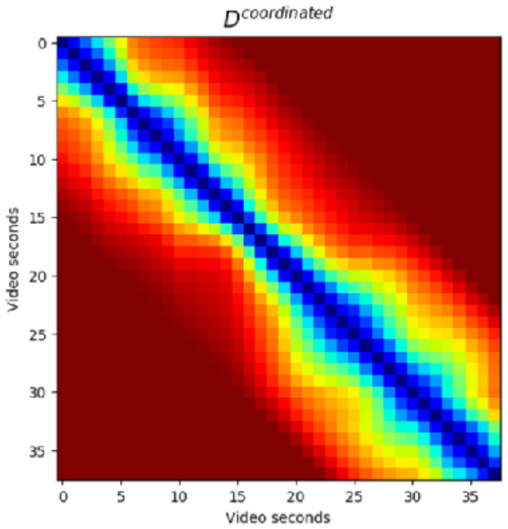


(Atencio et. al. , 2020) Query-based video summarization using machine learning and coordinated representations

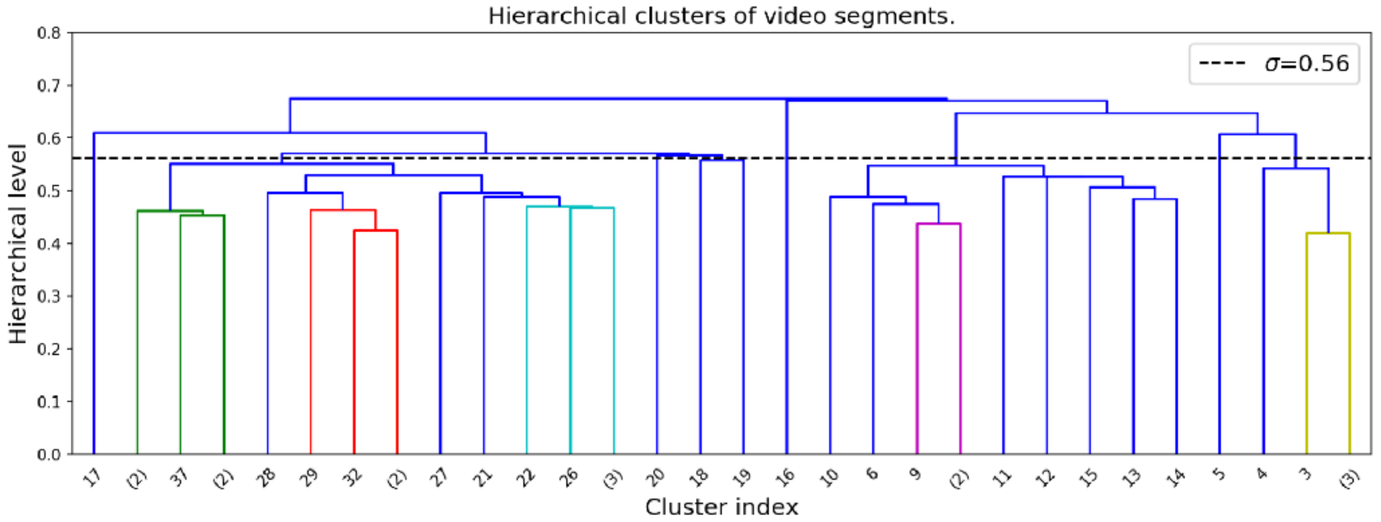
Video Summarization

$$w_{i,j}^{t} = \frac{1}{t} max(0, t - |i - j|)$$

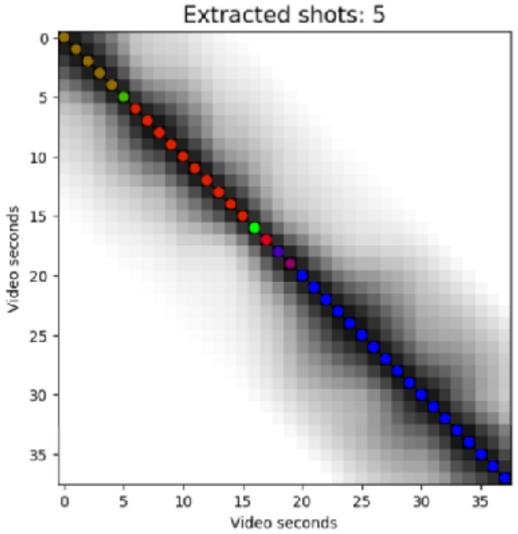
$$D_{i,j}^{coordinated}(C_i, C_j) = 1 - w_{i,j}^{t} e^{-\frac{1}{\Omega} cos(C_i, C_j)}$$



1) Disimilarity matrix.



2) Hierarchical clustering and threshold σ.



3) Extracted shots.

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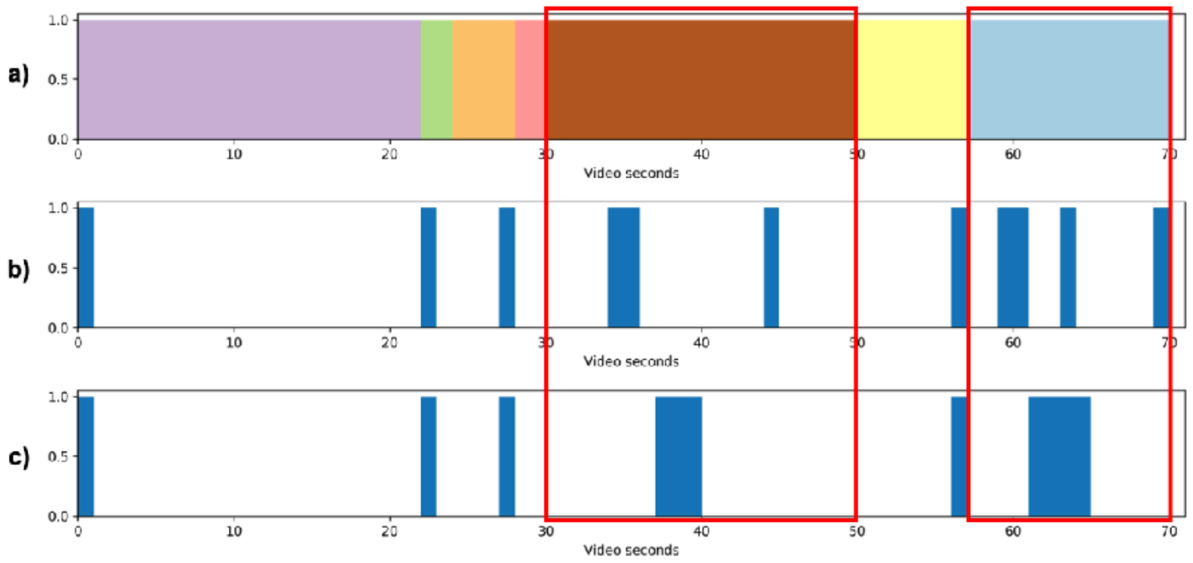
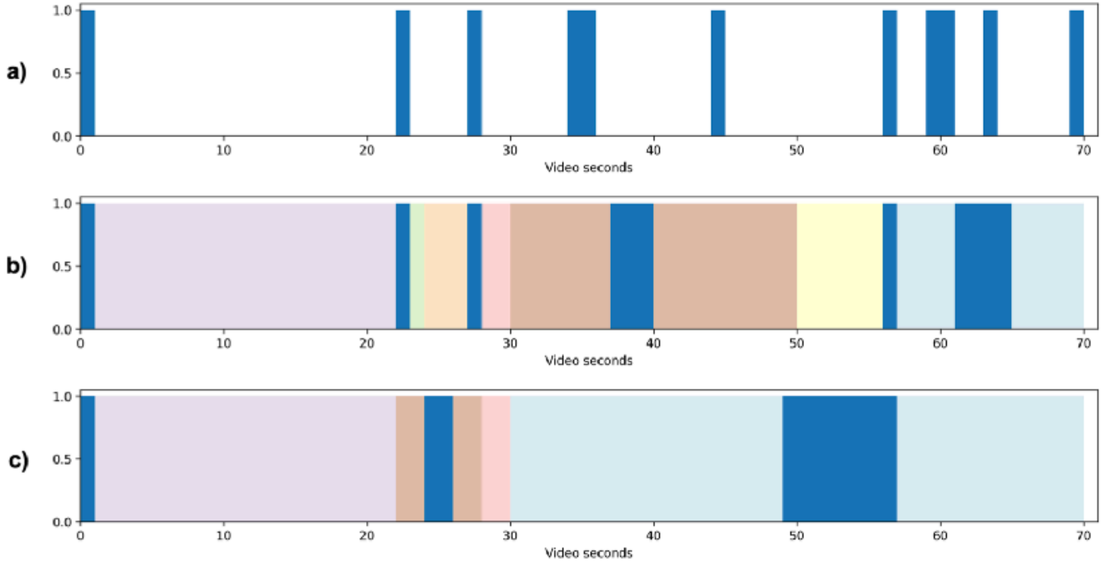
Video Summarization



(a) Extracted shots,. (b) k-medoids over coordinated space.
(c) Uniformity by mass-center.



Sensitivity control using hierarchical clustering parameter σ.

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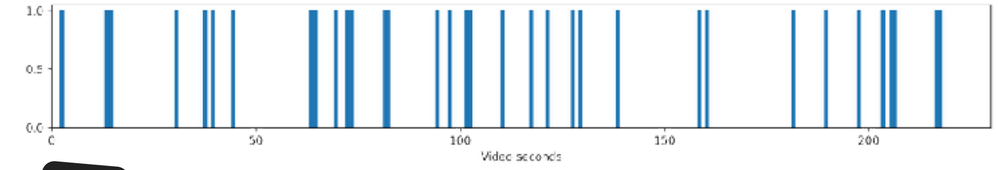
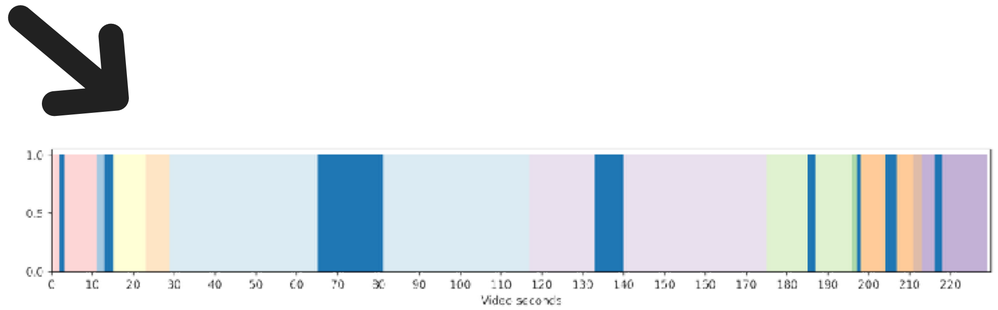
Video Summarization

Input Video





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Video Summarization

Representative Video Summarization (Live demonstration)

Conclusions

- Sequence summarization is a crucial task in computationally intensive task such as video analytics and text analytics.
- Extractive summarization is mainly unsupervised. On the contrary, abstractive summarization requires supervision, and therefore, human generated summaries.
- Hierarchical clustering allows to set sensitivity in extractive summarization tasks.