TUKALEIDOSCOPE SANTA FE 2018 Machine learning for a 5G future **Unsupervised Learning for Detection of Leakage from the HFC Network Emilia Gibellini Telecom** Argentina egibellini@teco.com.ar



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## Intro

Cable operators & MSO's delivery architecture: Hybrid Fiber/Coax (HFC)



Transmissions can be distorted when folds, breaks, corrosion of connectors, etc. occur.

We need to detect them  $\rightarrow$  PNM.



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## Measurement

Full-Band Capture:

- 24,000 measurements per cable modem
- 45 MHz to 1 GHz





## Methodology: cluster analysis

- Goal: find similarities & differences among observations
- Many algorithms
- Well-known technique: k-means



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## Methodology: k-means

- 1. Set K points as centers.
- 2. Calculate distances to centers.
- 3. Assign observations.
- 4. Evaluate & recalculate centers.

(repeat 2 - 5)

1.5 0.1 0.5 0.0 -0.5 0.0 0.5 1.0 1.5





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## Methodology

#### Challenge: define meaningful dimensions for the analysis.



Parallel coordinate plot, Fisher's Iris data



#### We can think of...

- Each frequency as a new dimension of analysis.
- Measurements on each modem as a vector.





## Methodology: to sum up...

- Algorithm: k-means
- K=6 (based on empirical methods)
- Distance: Euclidean
- 4,458 measurements per cable modem (frequencies where ingress may occur)
- Vectors of the form: X: {X<sub>1</sub>; X<sub>2</sub>; ...;X<sub>4,458</sub>}



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## Input

Examples:





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## Results

#### 88 MHz – 108 MHz:

- 3 & 6: acceptable noise.
- 1, 2, 4 & 5: "peaks"
- Peaks indicate ingress from FM radios.





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## Results

#### 869 MHz - 894 MHz:

- 2 & 6: internal noise only.
- 1, 4 & 5: "squared" shapes.
- 3: ~ "squared", less serious.
- Squared signals indicate 3G ingress.







## About the project





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## Latest results

LTE ingress on another (greater) sample:





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### **Latest results**

FM radio ingress on another (greater) sample:





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### Latest results

FM radio ingress in another sample:





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### Latest results

- Simpler way to characterize signals with impairments.
- Train anomaly detection (supervised) algorithm.

**O.K**.

Is it possible to extrapolate?





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## Conclusions

- The clustering method is useful for pattern detection.
- Easy to share and replicate.
- ✓ It provides a successful example of ML application.
  However...
- Early stage needs further analysis.
- Minimum requirements?
- Characterize sample to use as training set.
- Train supervised algorithm.
- Share is it generalizable?



Thank you



## **Methodology: find K**

#### **Elbow rule**

#### **Stable classes**



