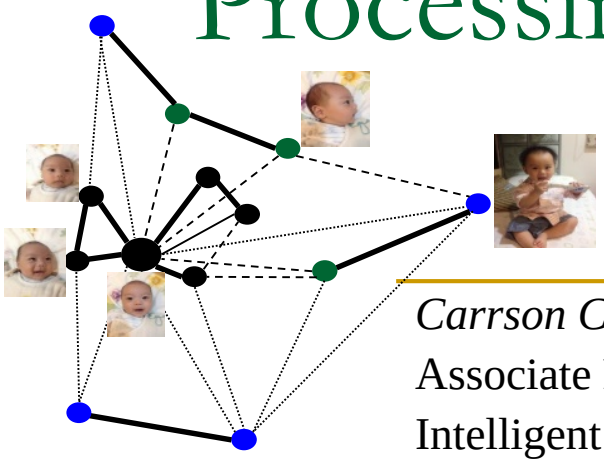
Data Science With Signal Processing



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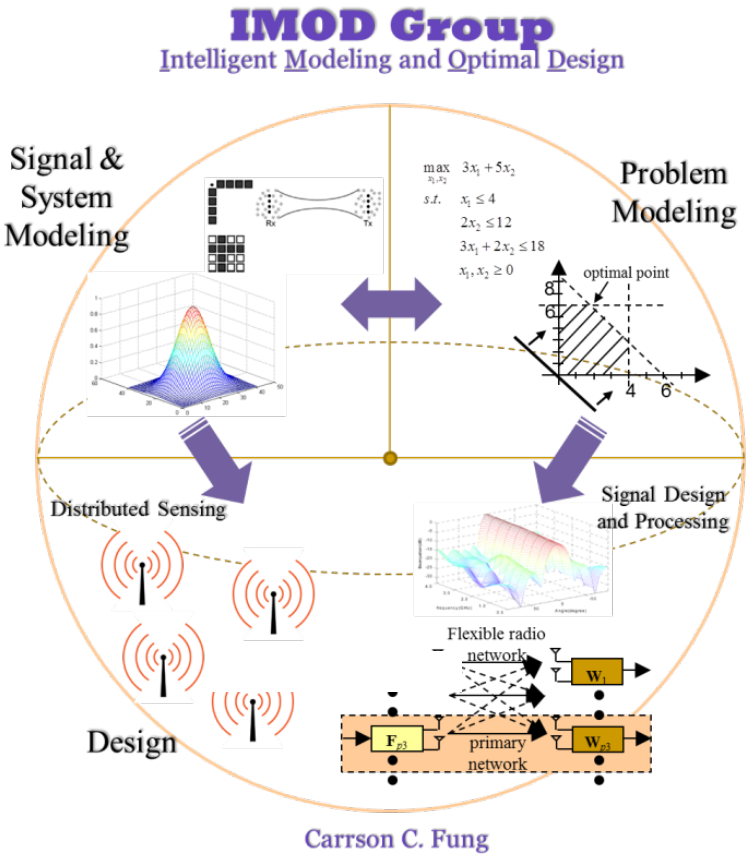
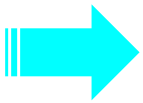
IMOD Group

- Research focuses on
  - **Self-supervised federated and distributed learning**
  - **Graph signal processing for graph learning and graph neural network**
  - **6G: Model-based DNN design for intelligent reflective surface (IRS)**
- Summer internship **abroad** for Ph.D. candidates are strongly encouraged (possible for outstanding M.S. students)
  - M.S. and 1st-year Ph.D. students encouraged to apply for the industrial Ph.D. program (教育部產學博計畫)
- Group members
  - 2 Ph.D., 5 M.S., 2 U.G.
- Possible to get jobs with skills you learned in my group
  - **Google** (Taipei and Mountain View), **Qualcomm** (San Diego), **Amobee** (Hsinchu), **Realtek** (Hsinchu), **Umbo Computer Vision**, Netapp (Los Angeles)



What I WON'T Do

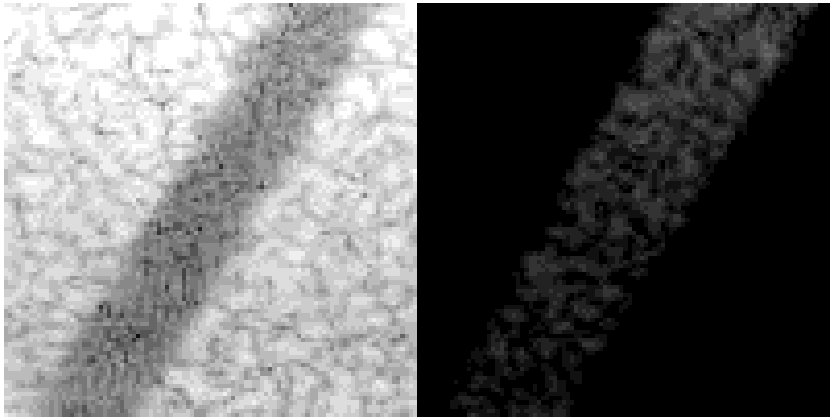
- Designing (and "optimizing"?) deep neural networks architecture for certain applications by trial and error
- Parameter tuning by trial and error
- Arbitrarily increase network size (and therefore hardware) to cope with more difficult problems



Design algorithms to solve specific problems in a **systematic manner**

Clutter Suppression in Ultrasound Video

Ground



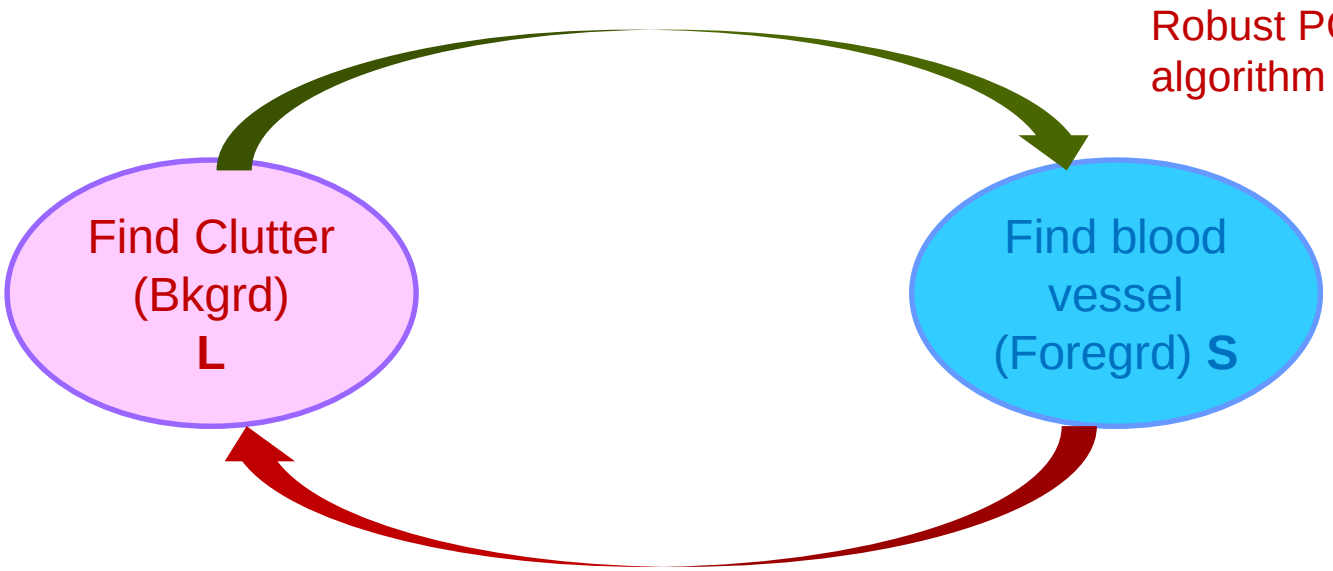
Model-based approach

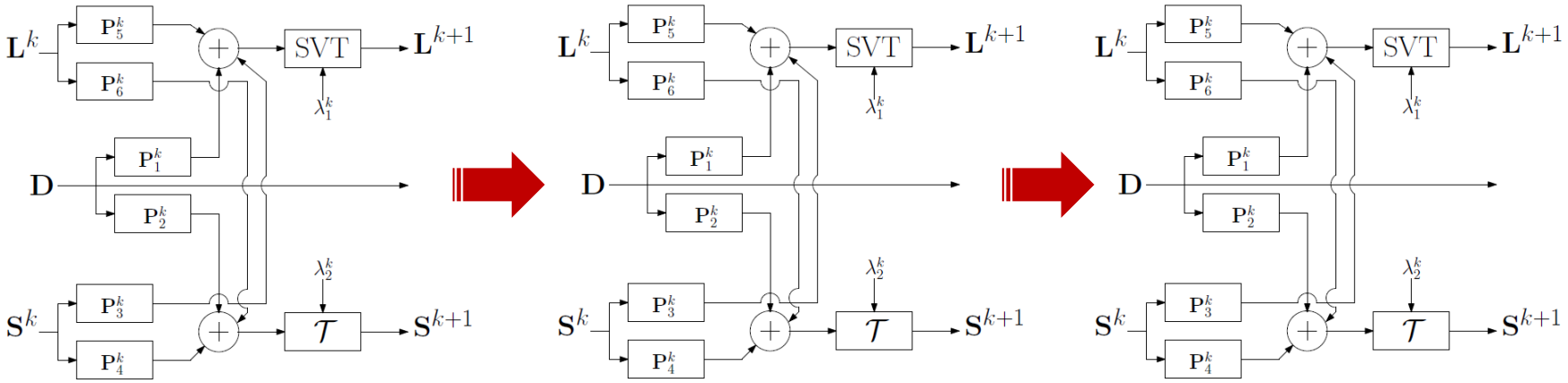
- Neural network obtained directly from optimization algorithm
- Provides explainability of results

10 layers of (Convolutional rObust pRincipal cOmpoNent Analysis)

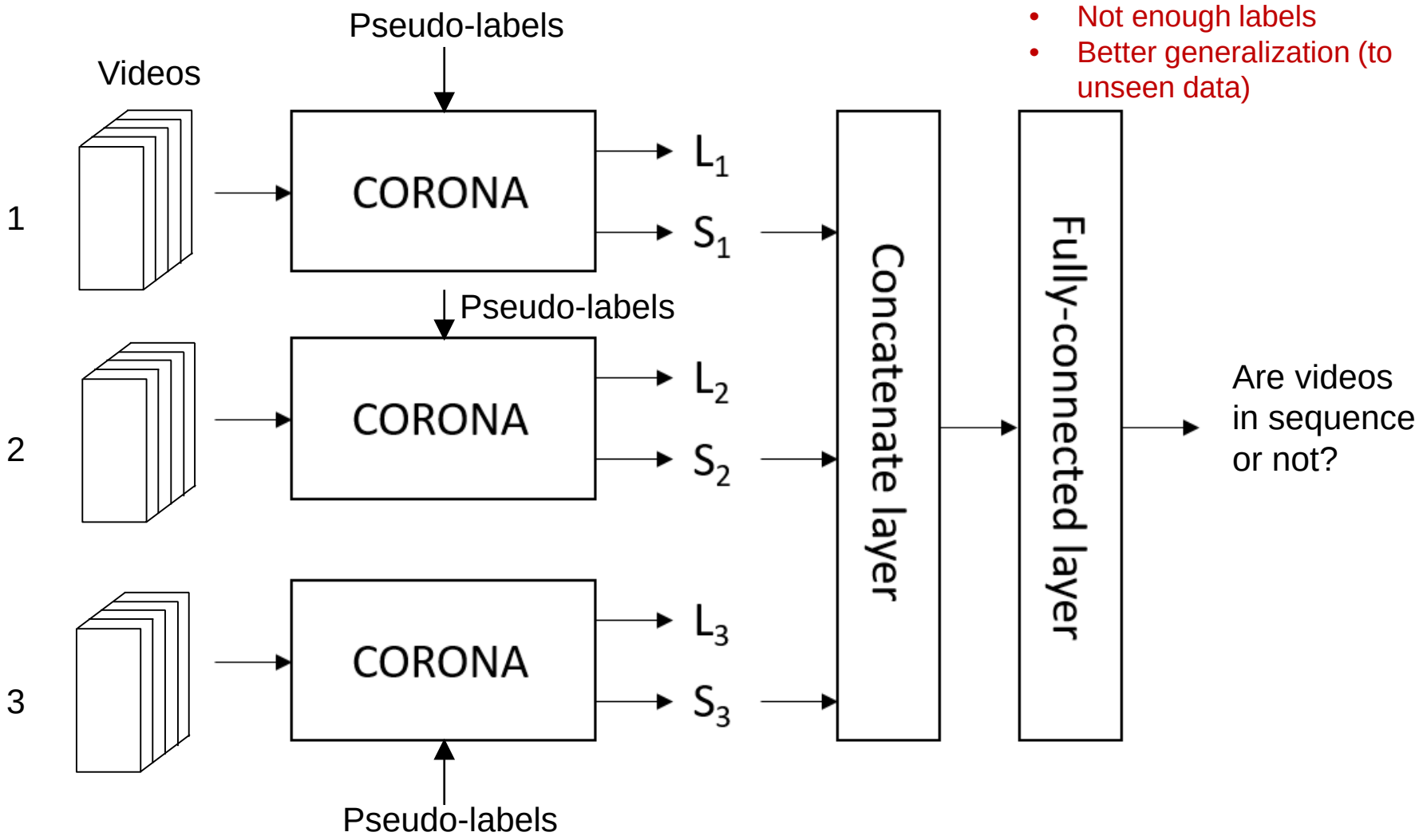
O. Soloman *et al.*, "Deep unfolded robust PCA with application to clutter suppression in ultrasound," *IEEE Trans. on Medical Imaging*, vol. 39(4), pp. 1051-1063, Sep. 2019.

Model Based DNN





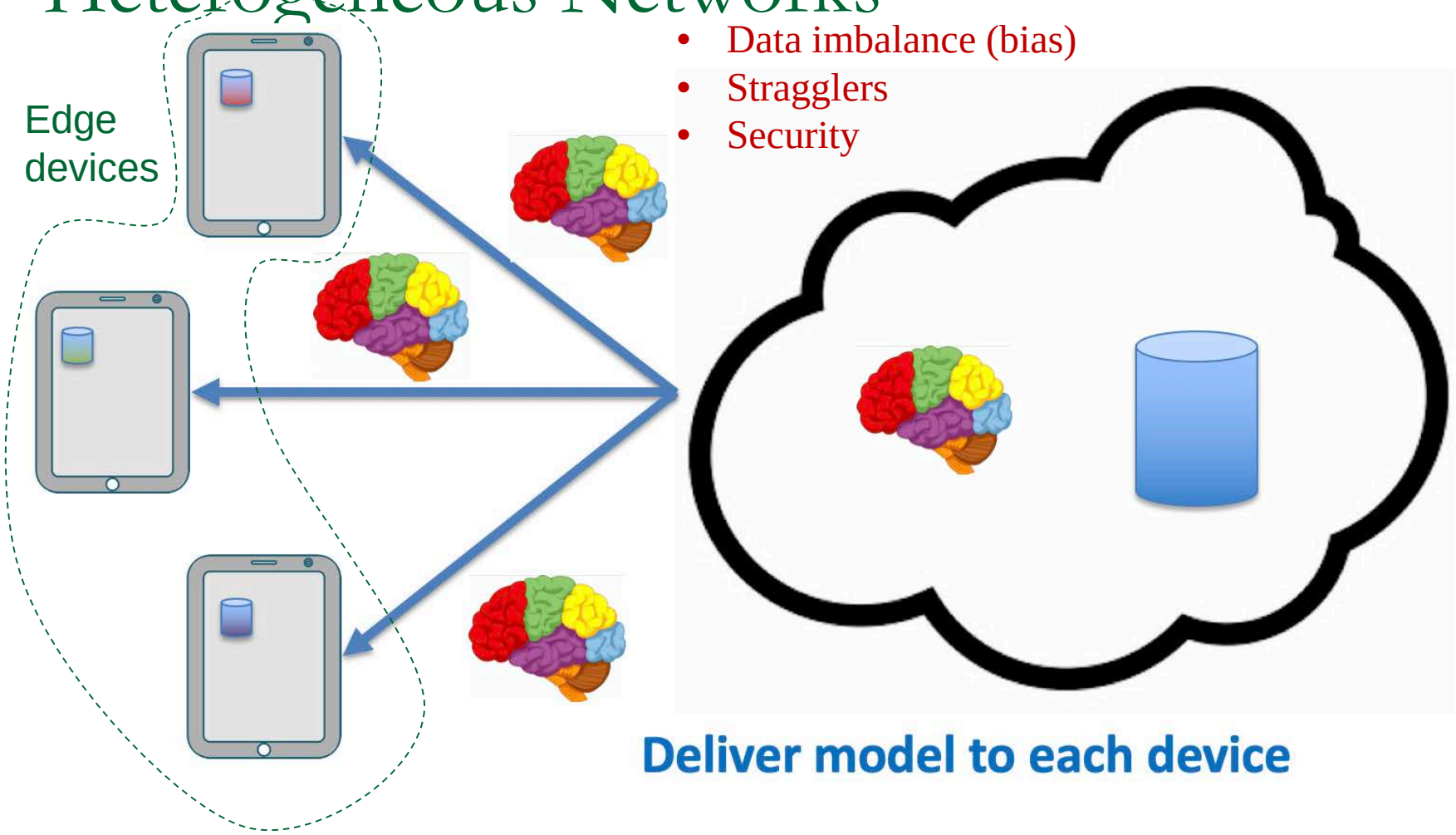
Self-Supervised Learning (SSL)



- Not enough labels
- Better generalization (to unseen data)

SS Federated and Distributed Learning in Heterogeneous Networks

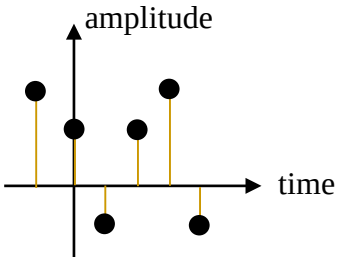
- Data imbalance (bias)
- Stragglers
- Security

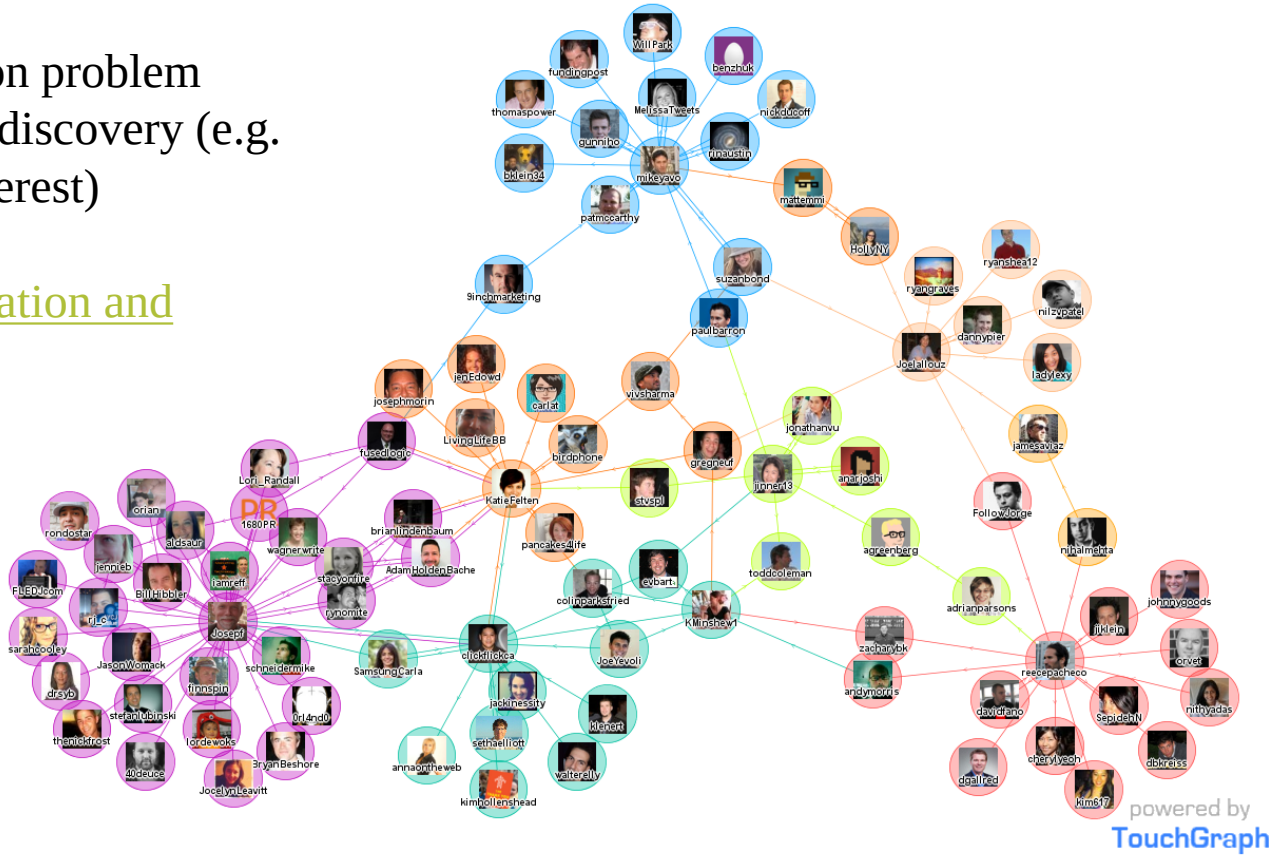


Signals on Graph: Information Network

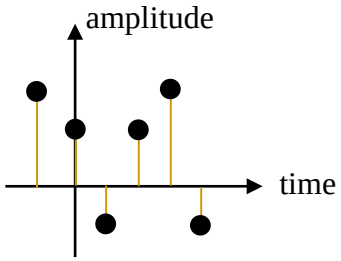
Sample applications:

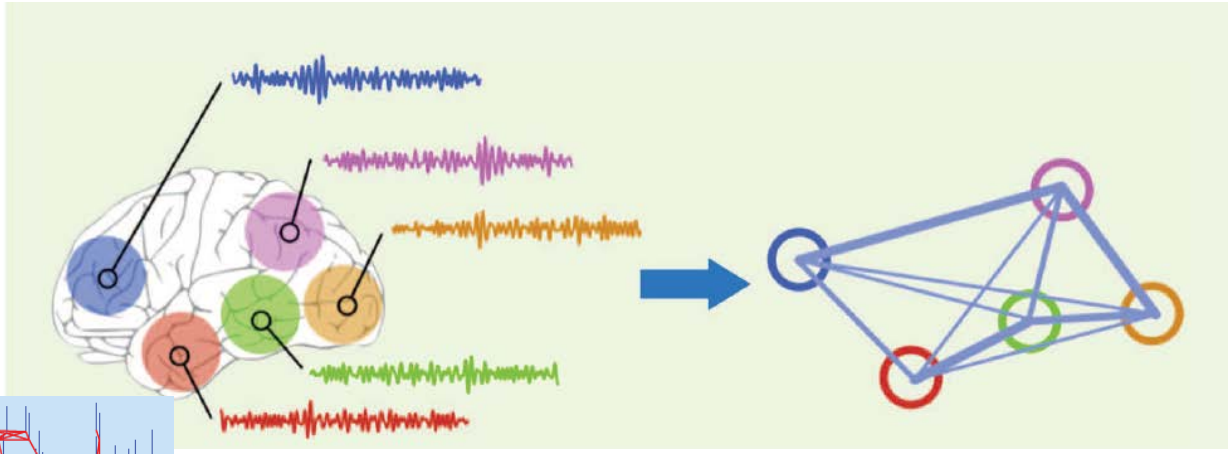
- Node classification problem
  - Community discovery (e.g. Netflix, Pinterest)
- Radar data association and tracking

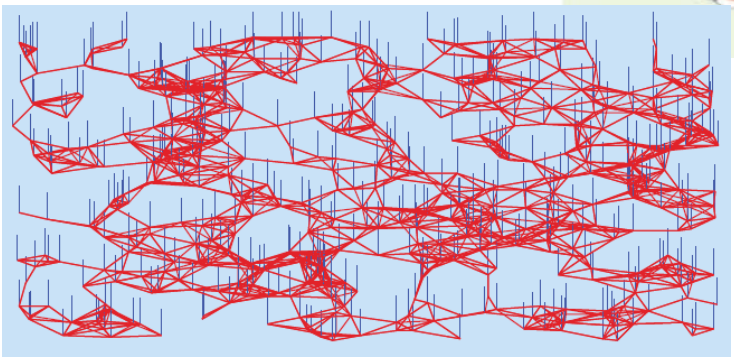




Signals on Graph: Brain Graph

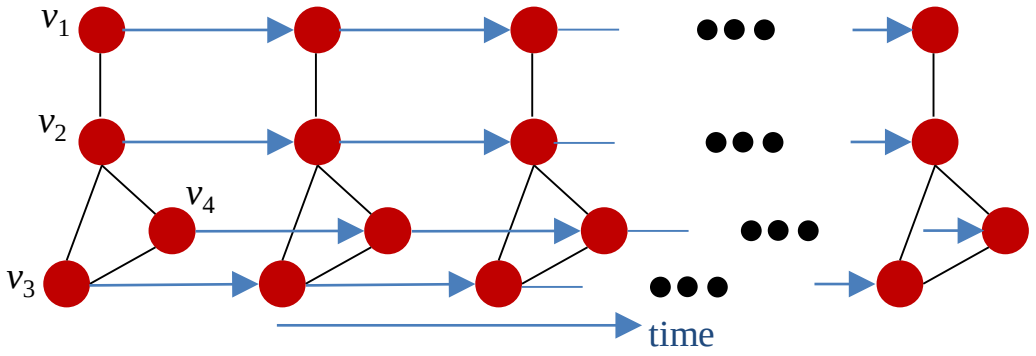




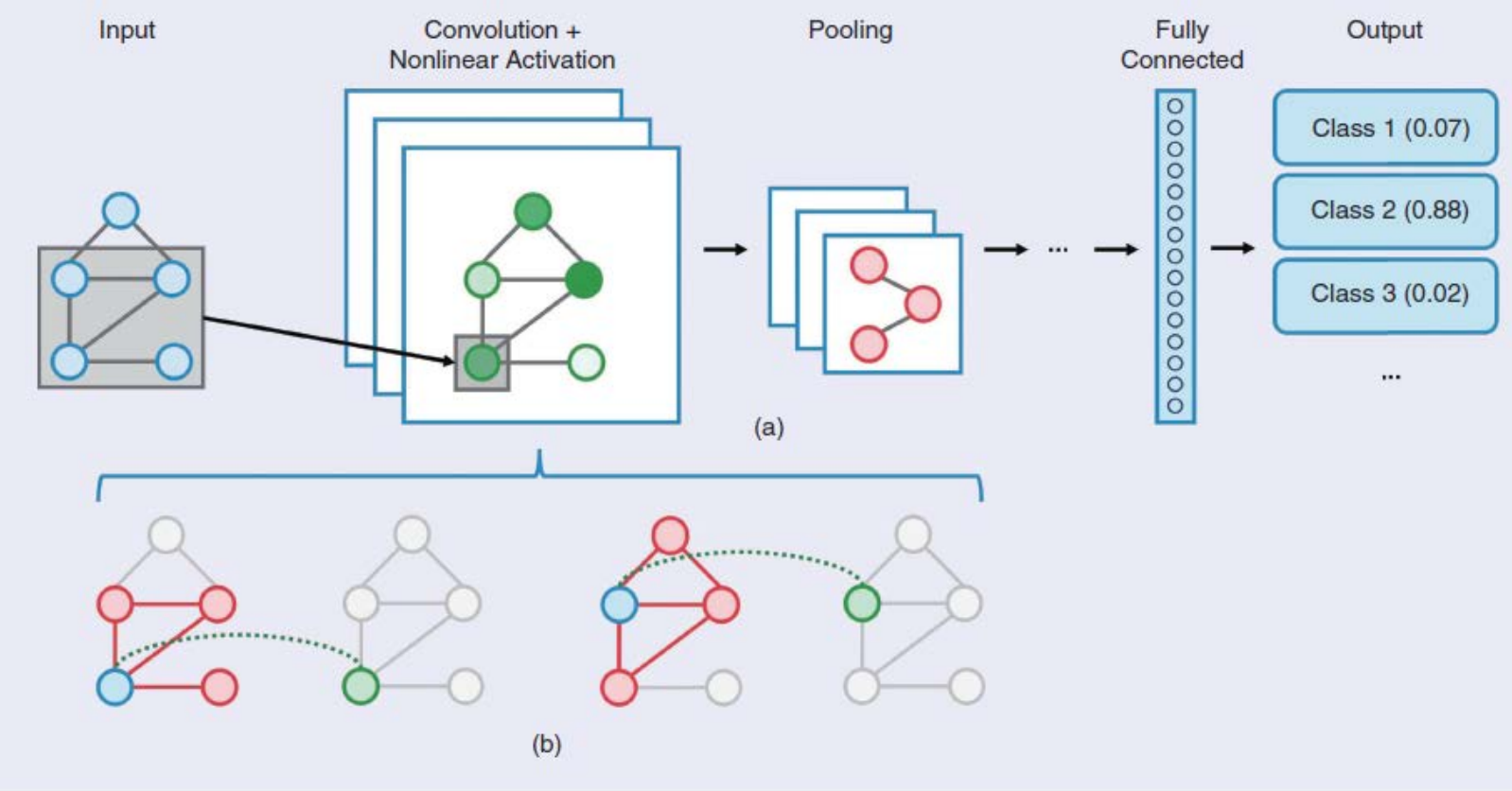


- **Learn the connectome of the brain over time: map of the neural connections in the brain**
  - **Structural –** white matter connection
  - **Functional –** statistical interdependencies between physiological time series from different brain regions
  - **Effective connectivity –** shows cause and effect of one neural element on another

Online graph learning (graph tracking)



Graph Neural Network



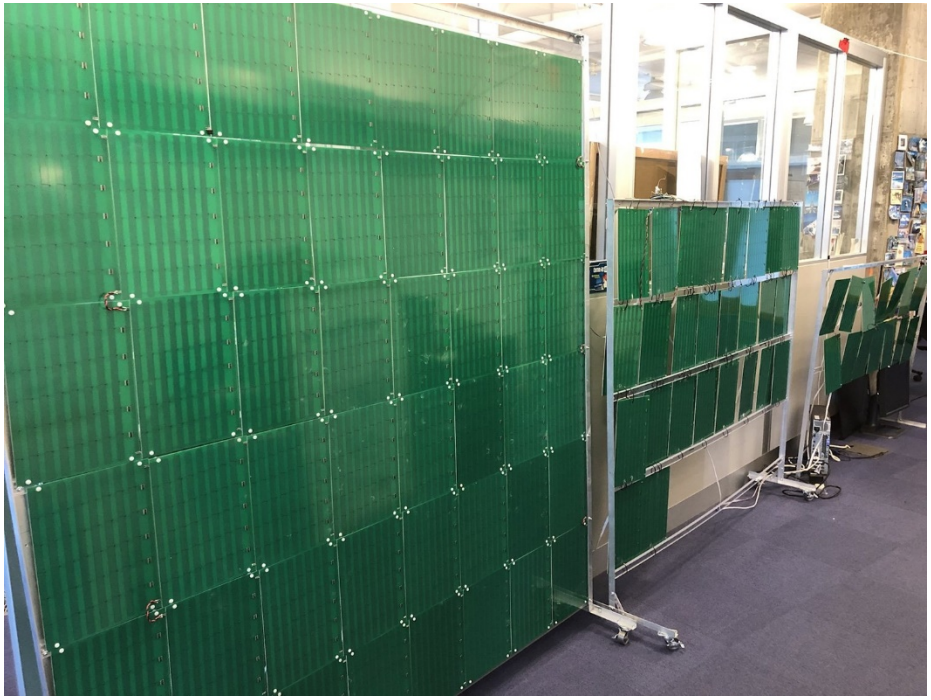
Graph classification

- Brain disease classification, e.g. Alzheimer's, Attention Deficit Hyperactive Disorder (ADHD)

How do we predict certain patient will have Alzheimer's or ADHD?

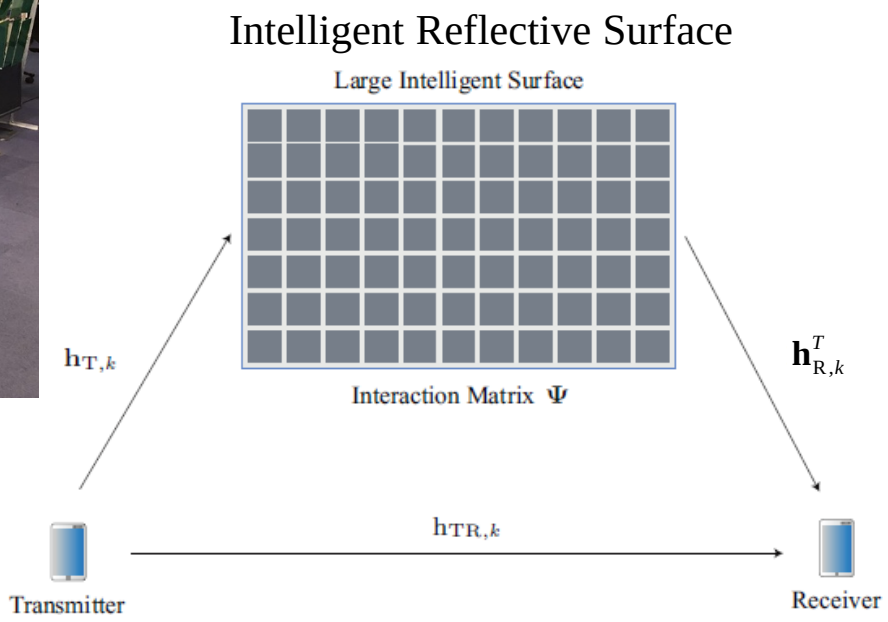
How should we take into account dynamic graph?

Model Based Neural Network for Intelligent Reflective Surface (IRS)



Source: https://www.techexplorist.com/mit-inexpensive-rforce-amplify-wi-fi-signal-ten-times/29708/

- **Joint transmitter and IRS design**
- **Channel estimation (large number of IRS elements is prohibitive)**
  - **Compressed sensing and model-based neural network**



What skills are required/learned to be successful?

- Good in mathematics and programming
  - Optimization, graph theory (graph signal processing), statistics, Matlab+Python/Julia
- Willingness and courage to explore and learn new (cross-disciplinary) subjects
- Ingenuity
- Be vocal, especially with your adviser

THEN MY GROUP IS FOR YOU!!!
Stop by and talk to me (ED 639)!
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or Google "Carrson Fung"

3D mmWave Radar