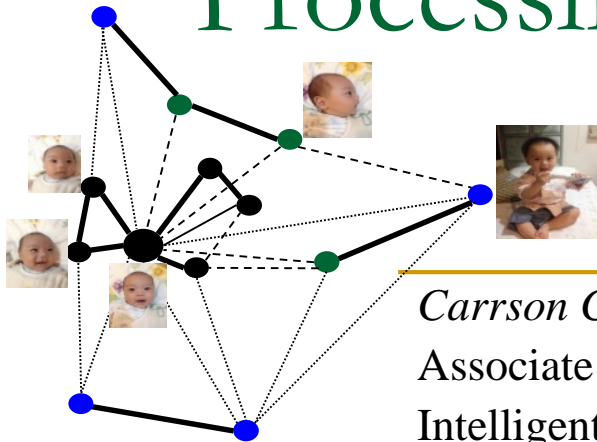


# Data Science With Signal Processing



*Carrson C. Fung*

Associate Professor

Intelligent Modeling and Optimal Design Group (IMOD)

Communication Electronics and Signal Processing Lab (CommLab)

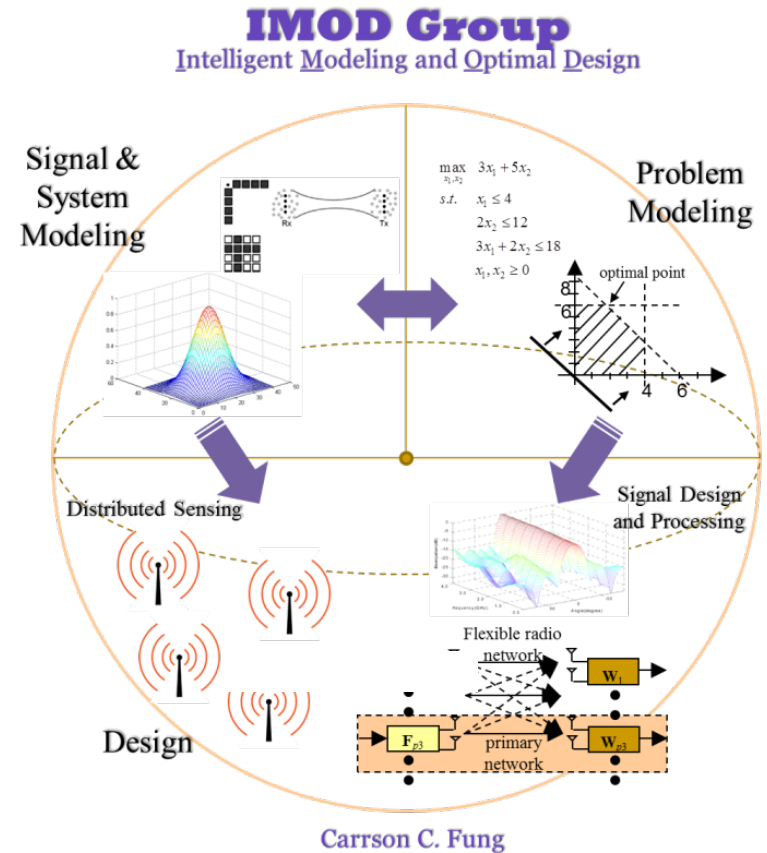
Institute of Electronics

National Chiao Tung University



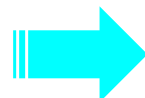
# IMOD Group

- 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 1<sup>st</sup>-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

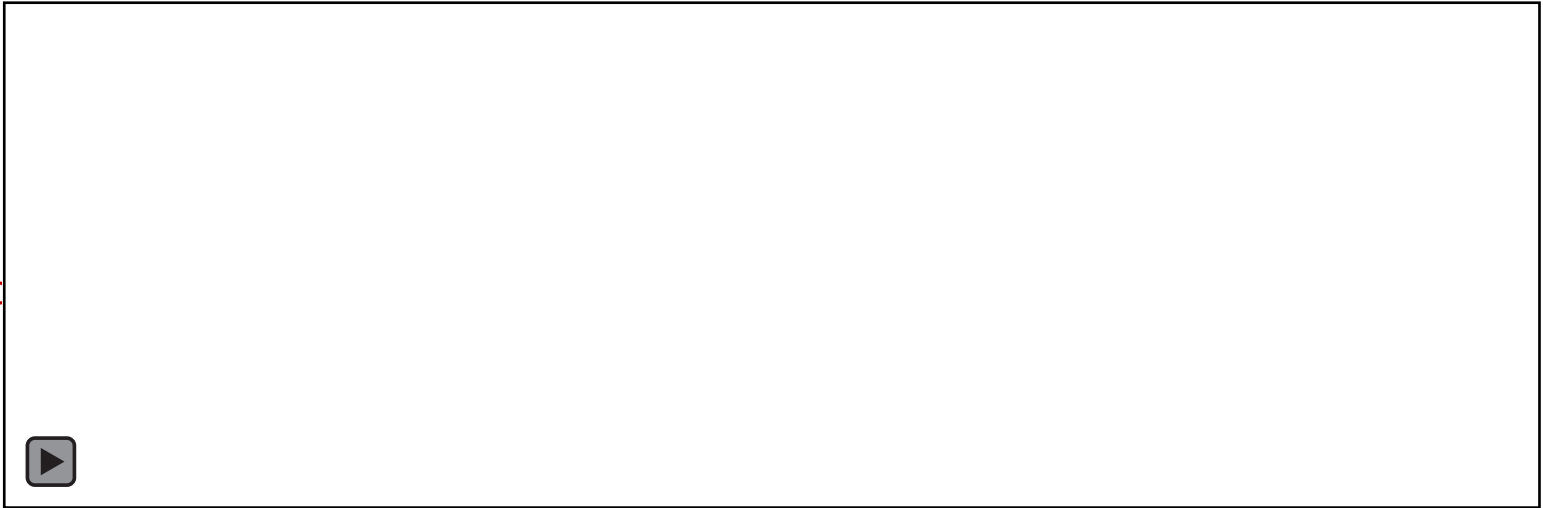
- Designing (and “optimizing”?) deep neural networks architecture for certain applications by trial and error
- Parameter tuning by trial and error
- Arbitrarily increase network size (and therefore hardware) to cope with more difficult problems

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



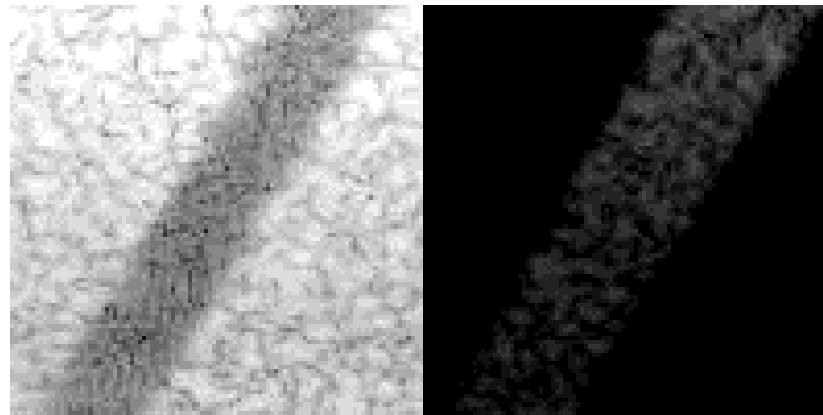
# Clutter Suppression in Ultrasound Video

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.

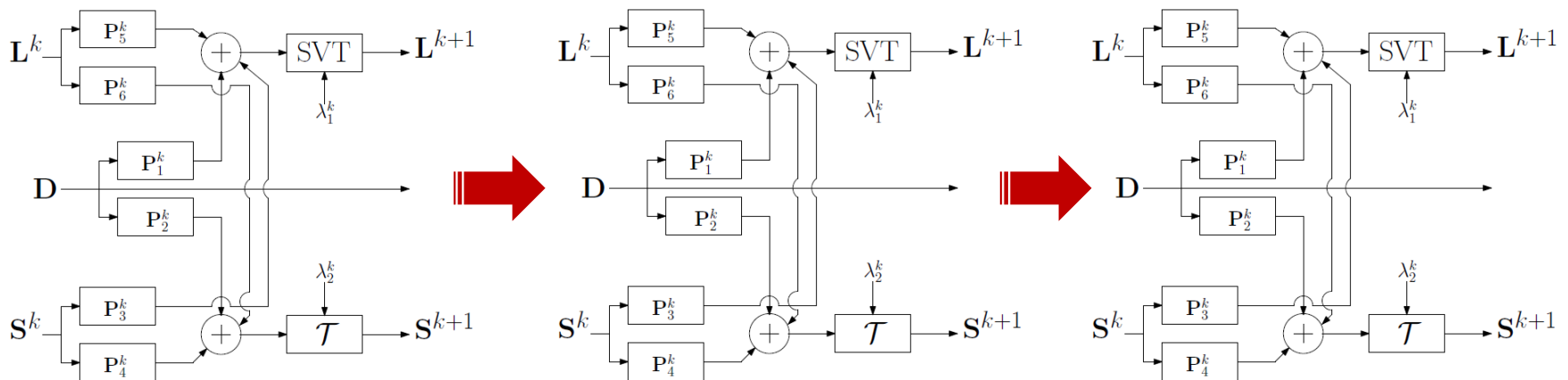


# Model Based DNN

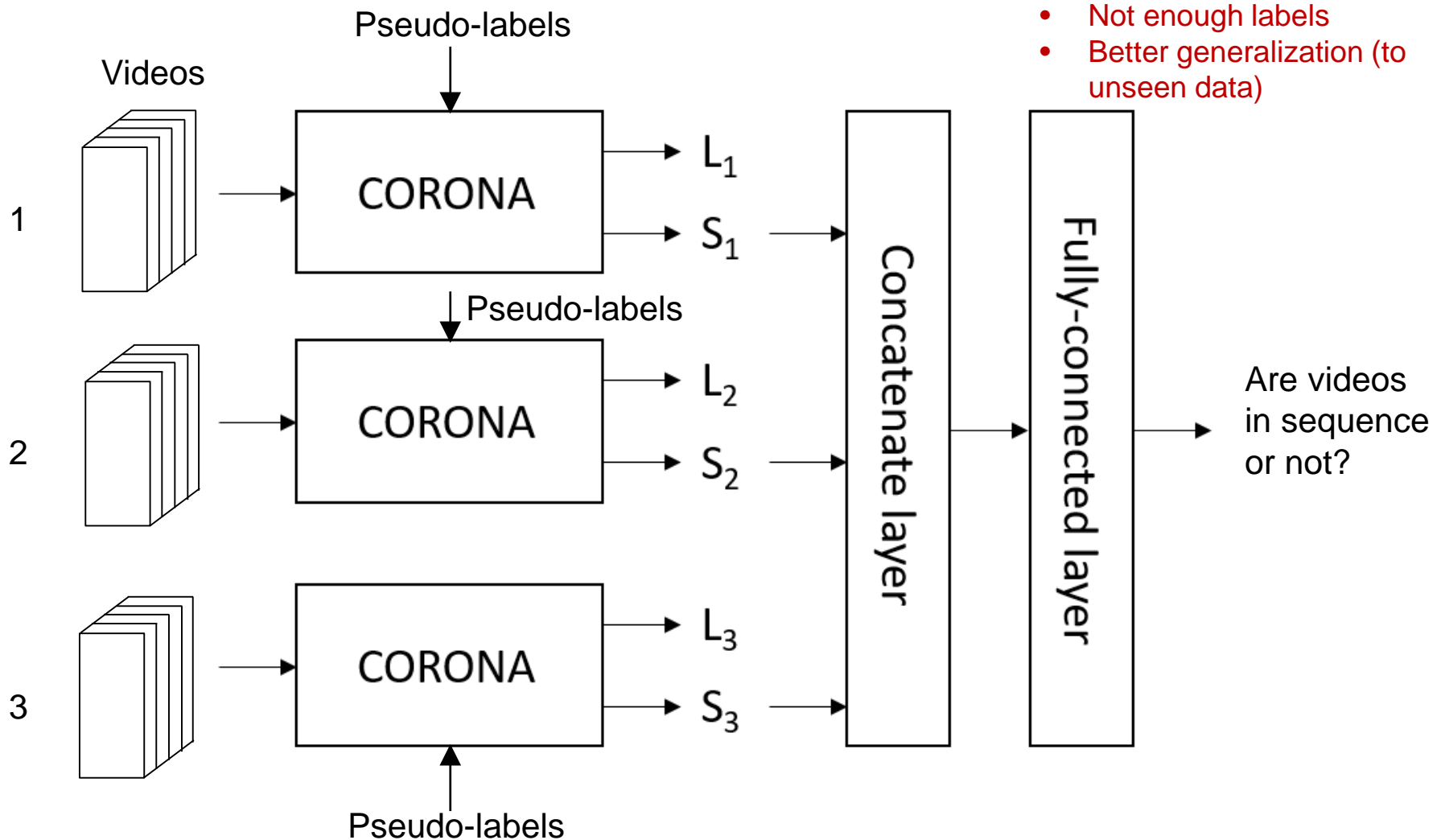
Robust PCA  
algorithm

Find Clutter  
(Bkgrd)  
 $L$

Find blood  
vessel  
(Foregrd)  $S$



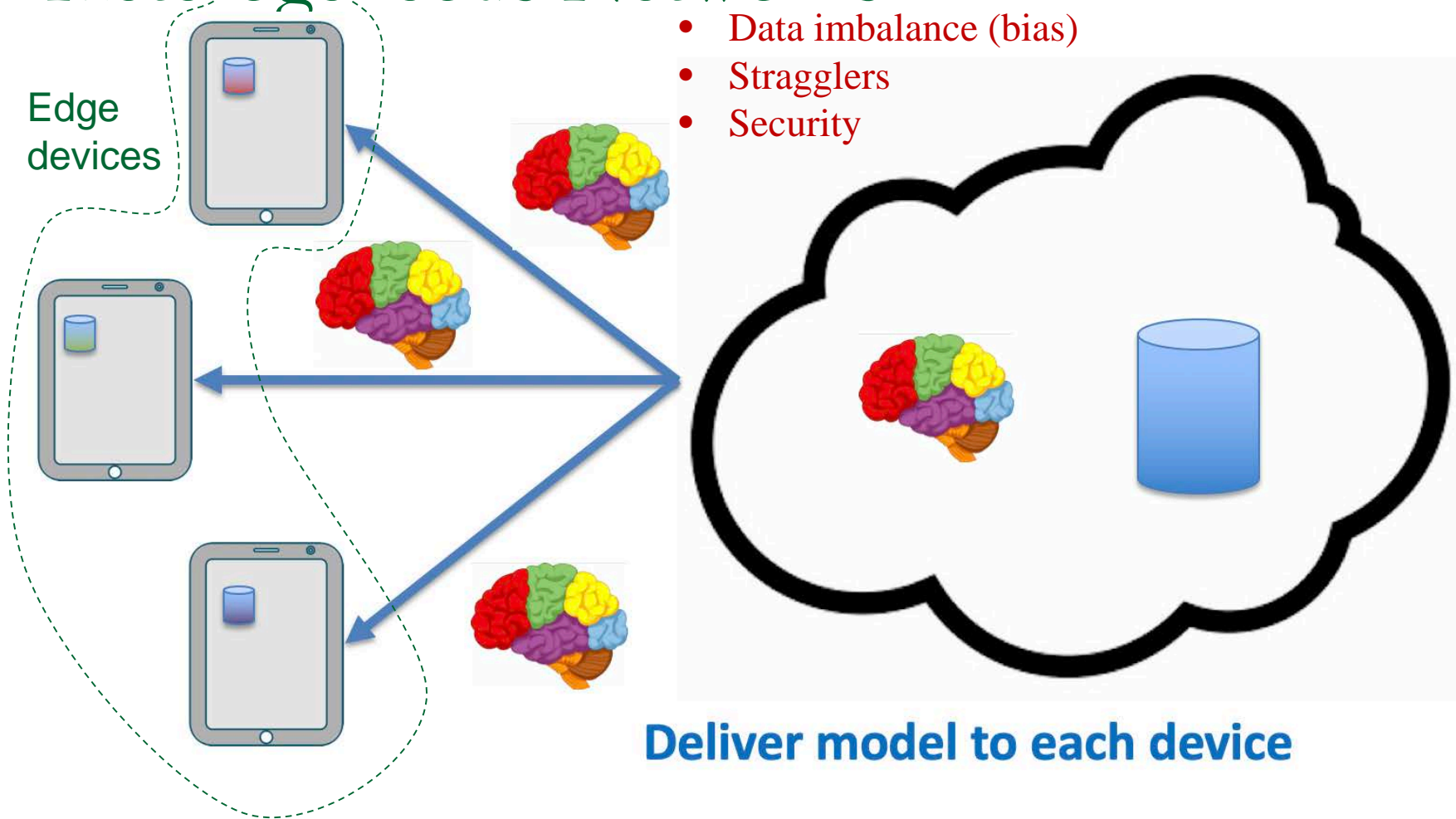
# Self-Supervised Learning (SSL)



# SS Federated and Distributed Learning in Heterogeneous Networks

- Data imbalance (bias)
- Stragglers
- Security

Edge devices



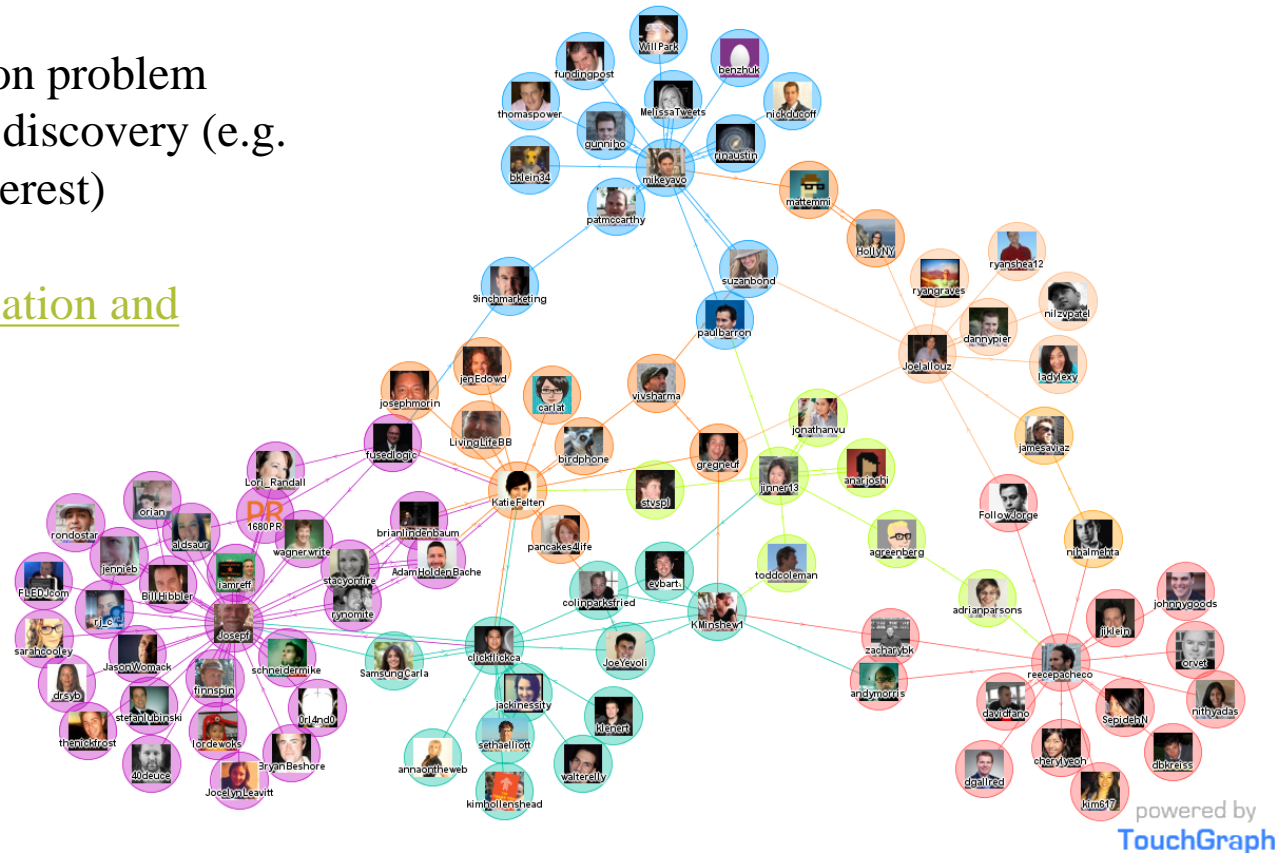
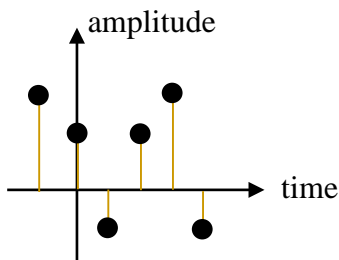
**Deliver model to each device**



# Signals on Graph: Information Network

## Sample applications:

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

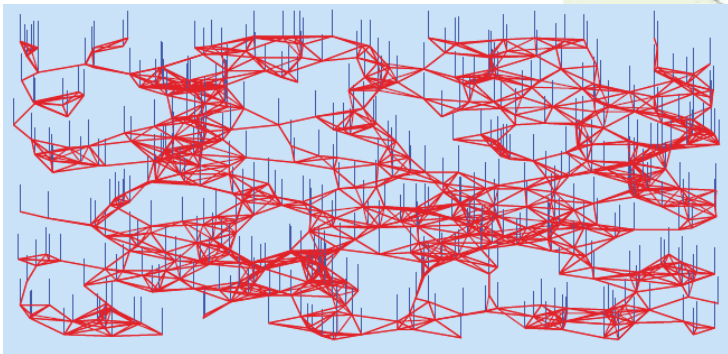
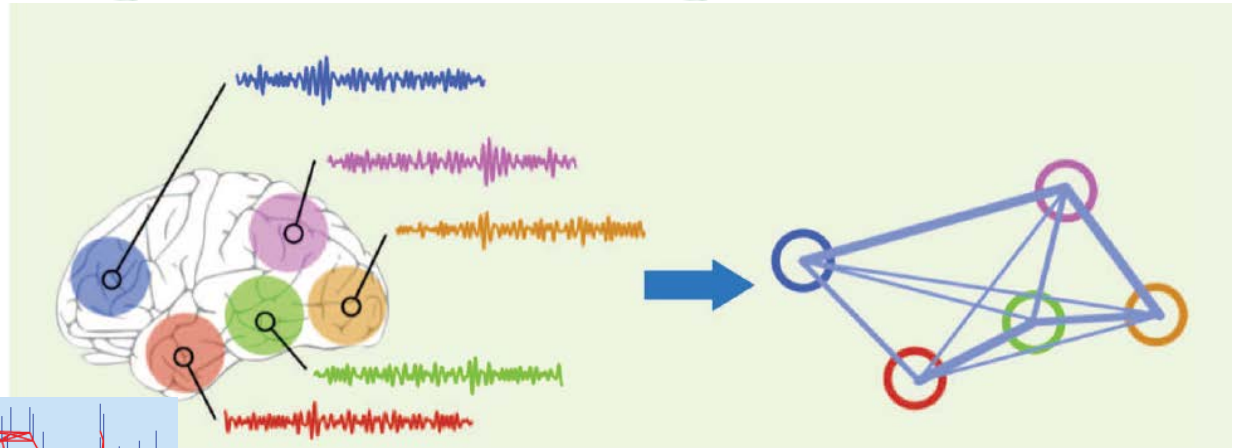
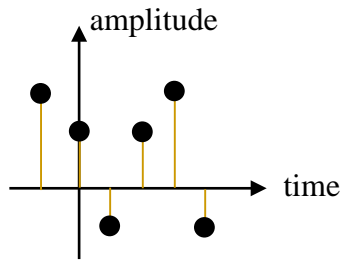


powered by  
TouchGraph



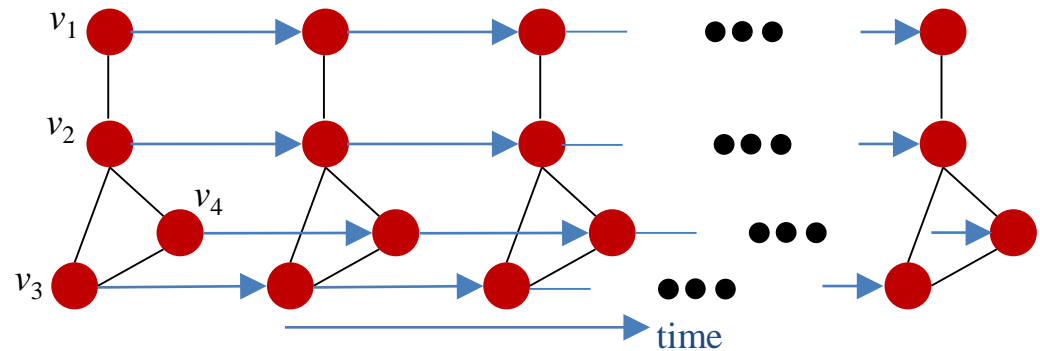


# Signals on Graph: Brain Graph

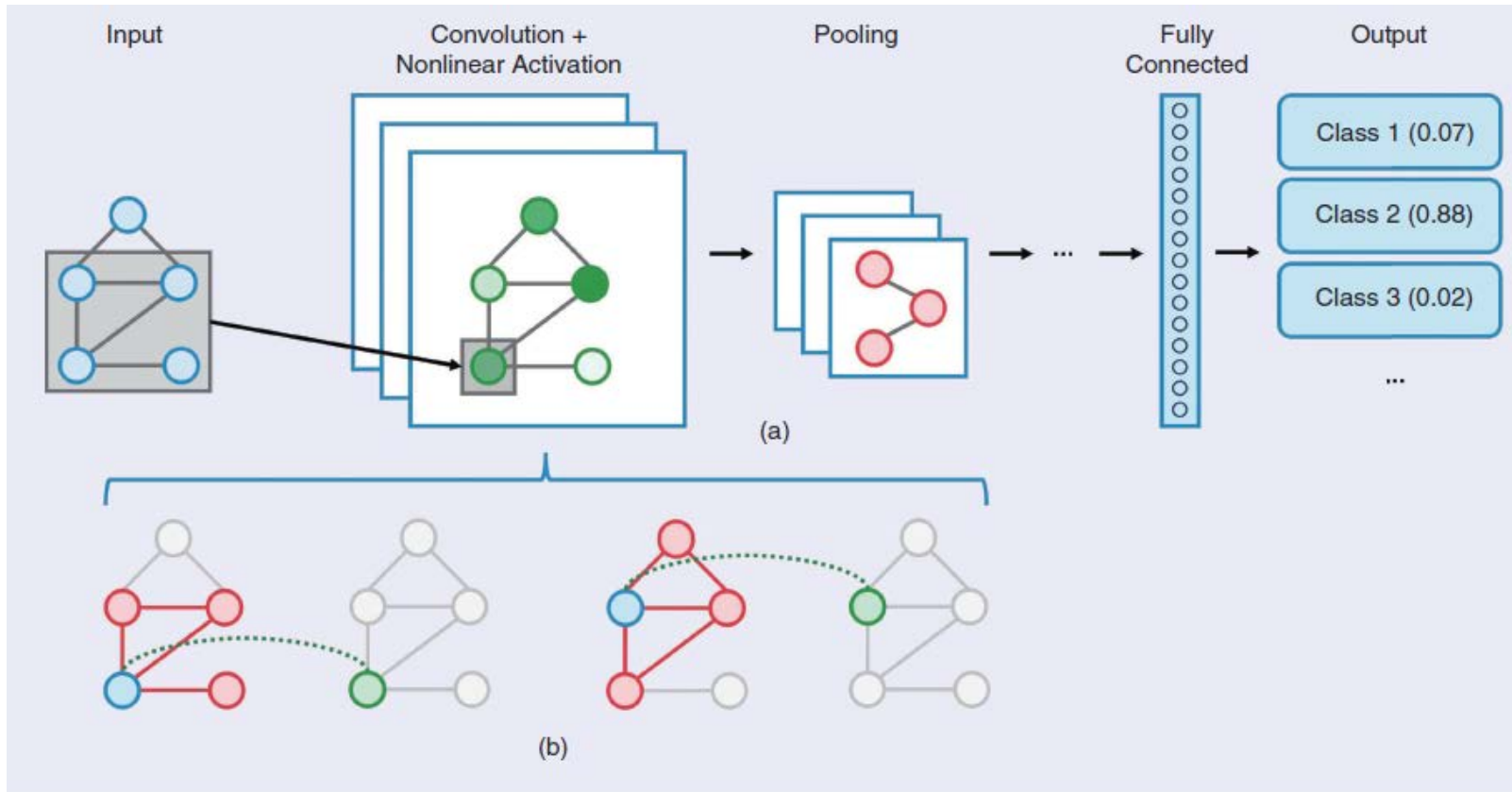


- Learn the **connectome** of the brain **over time**: map of the neural connections in the brain
  - **Structural** – white matter connection
  - **Functional** – statistical interdependencies between physiological time series from different brain regions
  - **Effective connectivity** – shows cause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

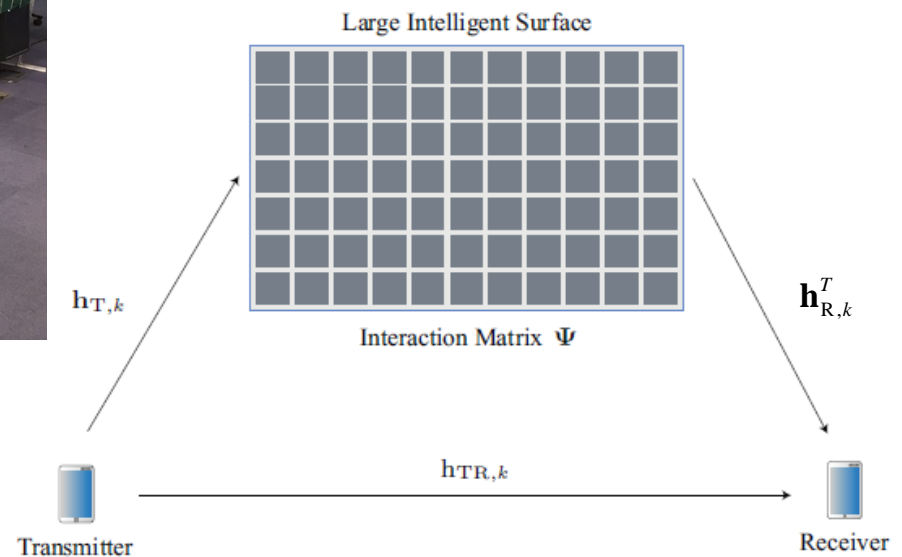
# Model Based Neural Network for Intelligent Reflective Surface (IRS)



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**

## Intelligent Reflective Surface



# 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)!**

***[c.fung@ieee.org](mailto:c.fung@ieee.org)***

***<https://mcube.lab.nycu.edu.tw/~cfung>***

**or Google “Carrson Fung”**





# 3D mmWave Radar

The screenshot displays the DriveRecorder3 software interface. The main window shows a top-down view of a red car with a yellow radar cone and several cyan circular targets. The interface includes several panels:

- Controller:** Shows file sources for CANData (20160929\_0300.dr2) and Video (20160929\_0300.avi).
- HW Monitor:** Displays status for CAN1 (1000k) and video capture (No CAN-HW found!).
- TargetList I & II:** Lists detected targets, currently showing 'Umrz2GID0'.
- TargetDraw & CSV Export:** Provides controls for drawing targets and exporting data.
- Status I & II:** Shows tracking data for TrackingBSD1 and TrackingBSD2, including fields like Device\_Mode, Source\_Device, Source\_Diagnosis, Time [s], Number\_Of\_Objects, and Number\_Of\_Messages.
- Video:** A live video feed showing a person walking in an outdoor setting.
- CANDataGrid:** A table displaying CAN bus data.

#Msgs	Ident	Len	Data bytes [7...0]	CAN Nr	CANCard-Time
99	1F5	8	1E.FF.FF.CE.00.00.00.1	1	1805783210
196	400	7	00.00.00.00.00.00.01	1	1805752948
2778	401	8	87.8C.1C.1C.27.C8.D1.1	1	1805766407
2778	402	7	04.00.00.02.1A.00.1D	1	1805766635
196	410	7	00.00.00.00.00.00.01	1	1805767080
3564	411	8	80.2C.10.14.29.60.FB.1	1	1805782793

