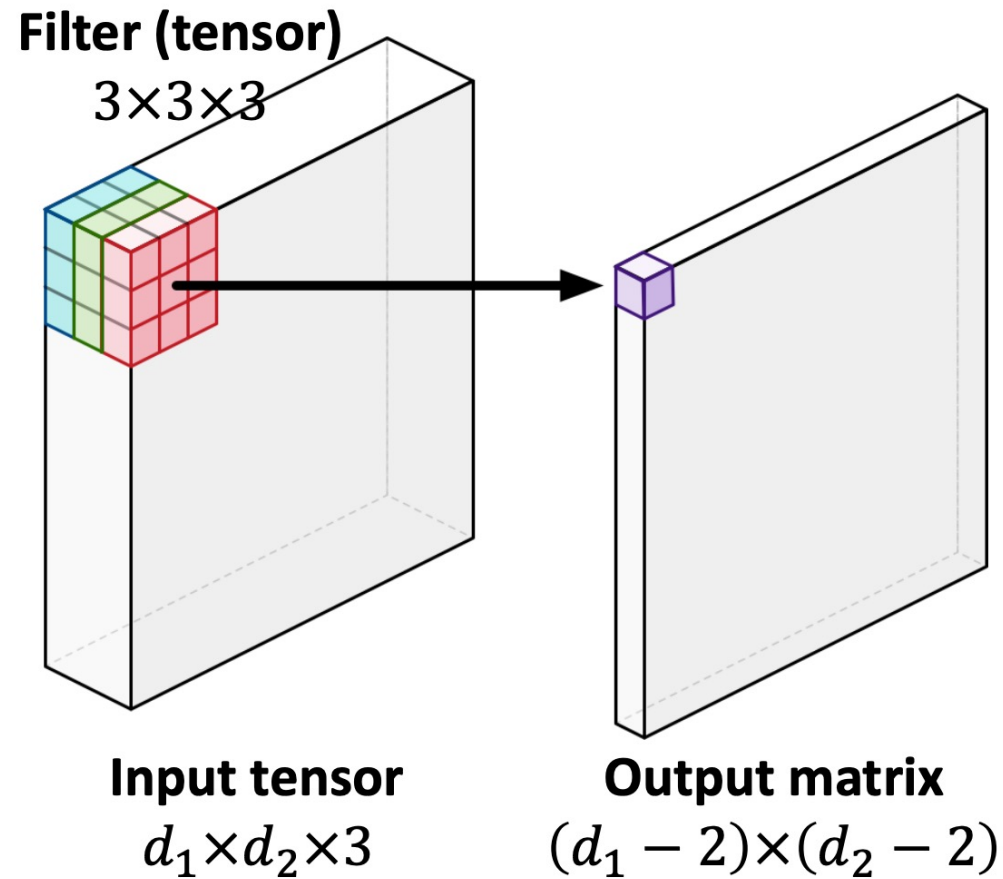


Graph Data in ML

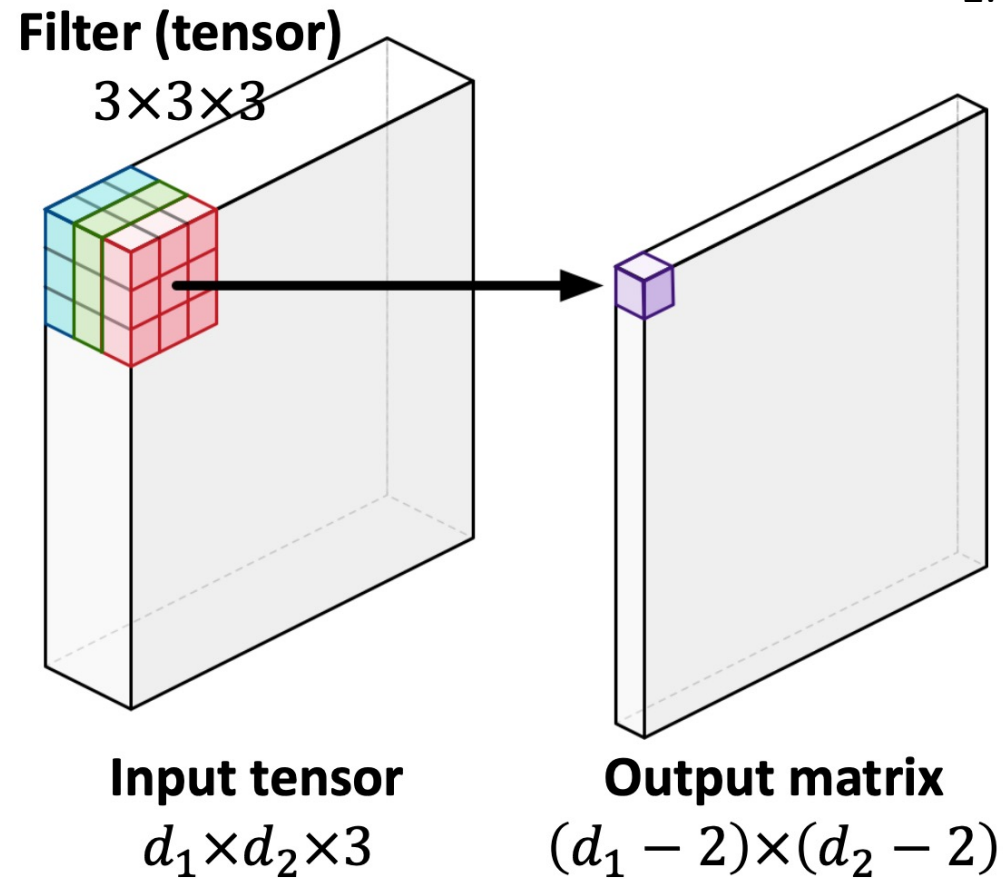
Neural Networks Design And Application

Correlation between data



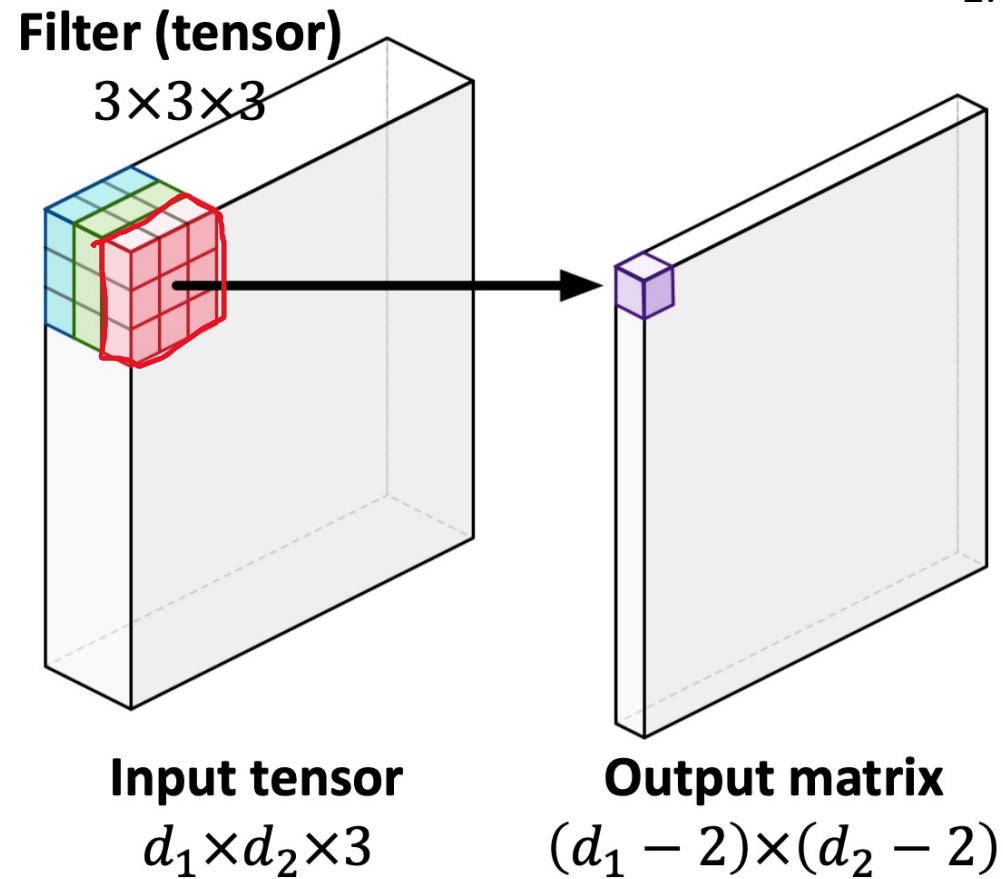
Correlation between data

Q: is there correlation between:
1. locations?

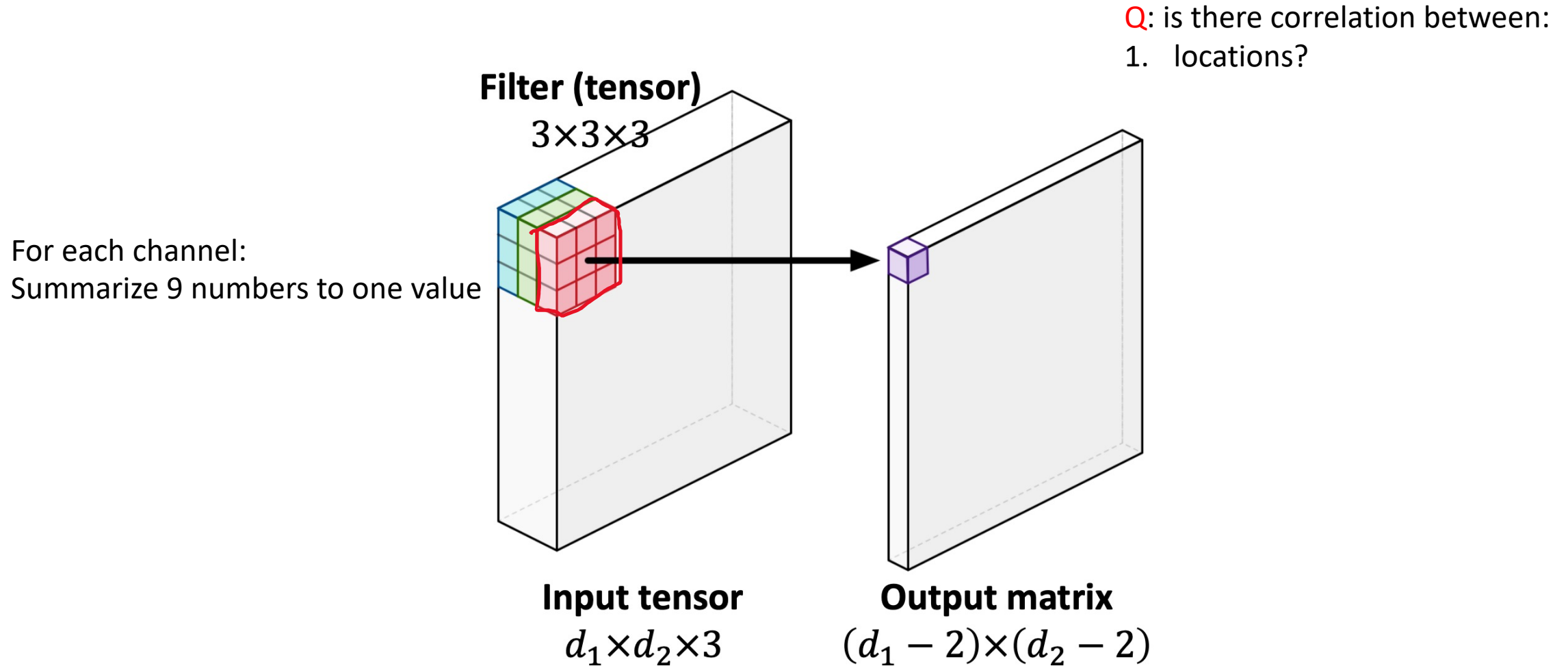


Correlation between data

Q: is there correlation between:
1. locations?



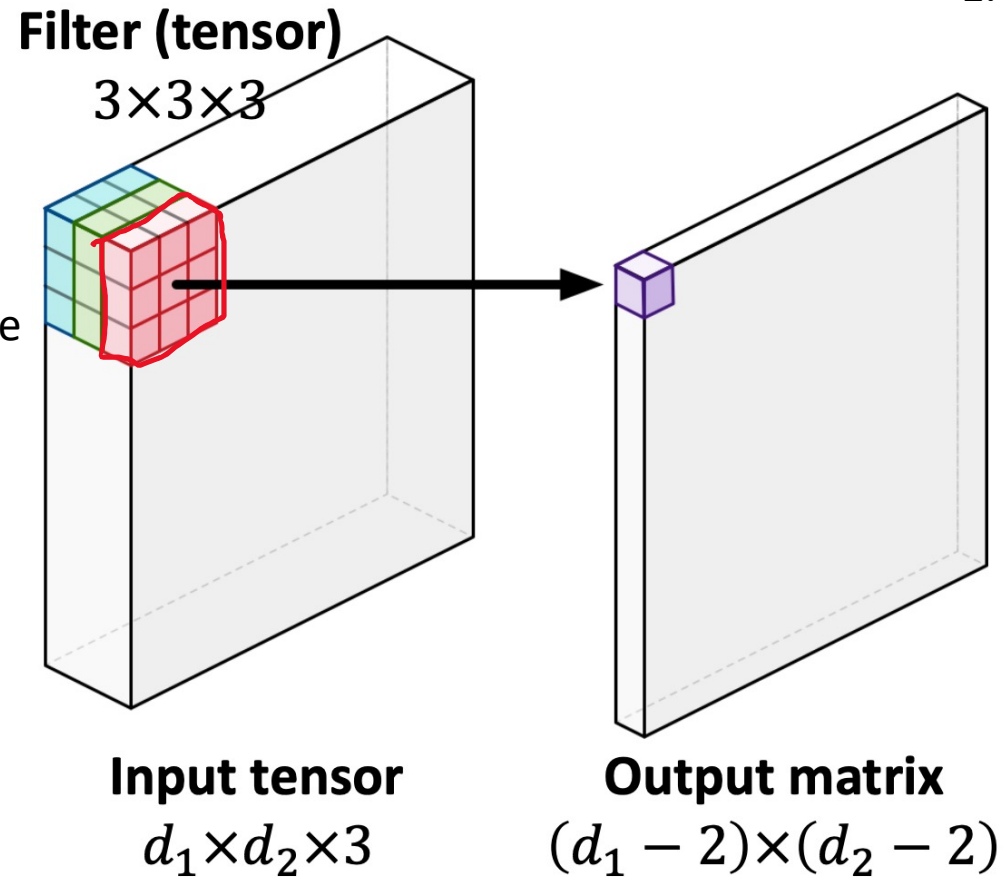
Correlation between data



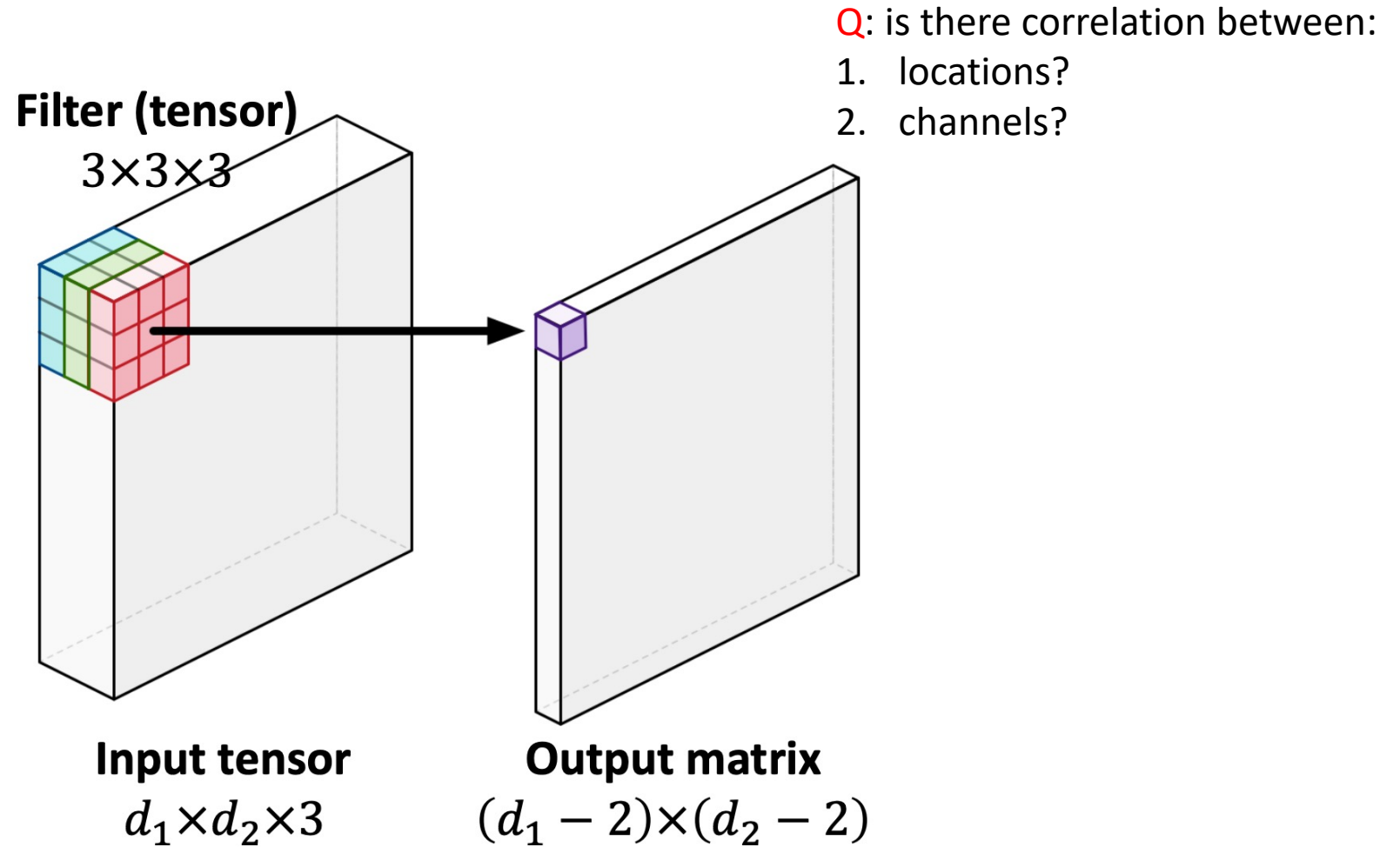
Correlation between data

Q: is there correlation between:
1. locations?

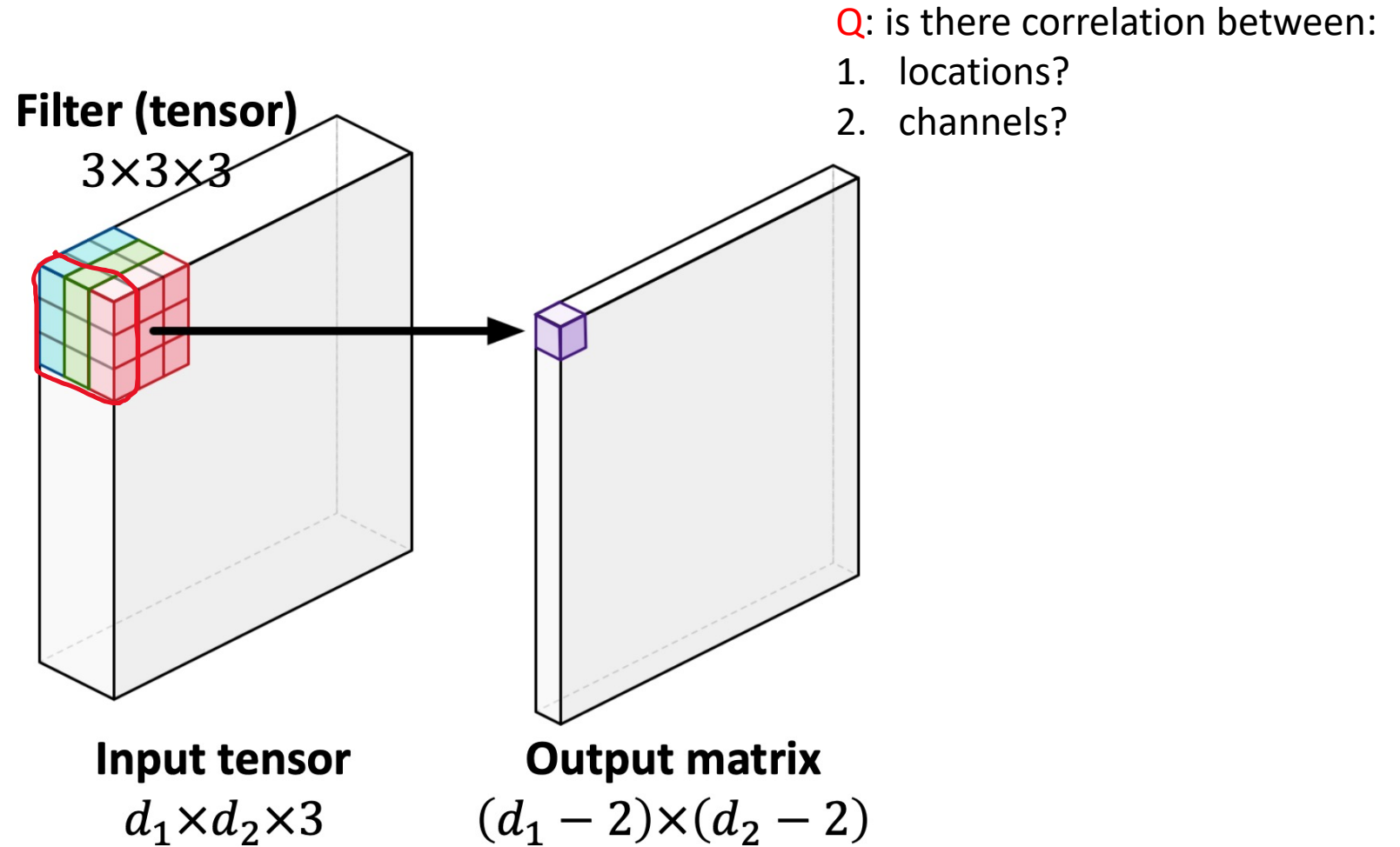
For each channel:
Summarize 9 numbers to one value
(correlation among locations)



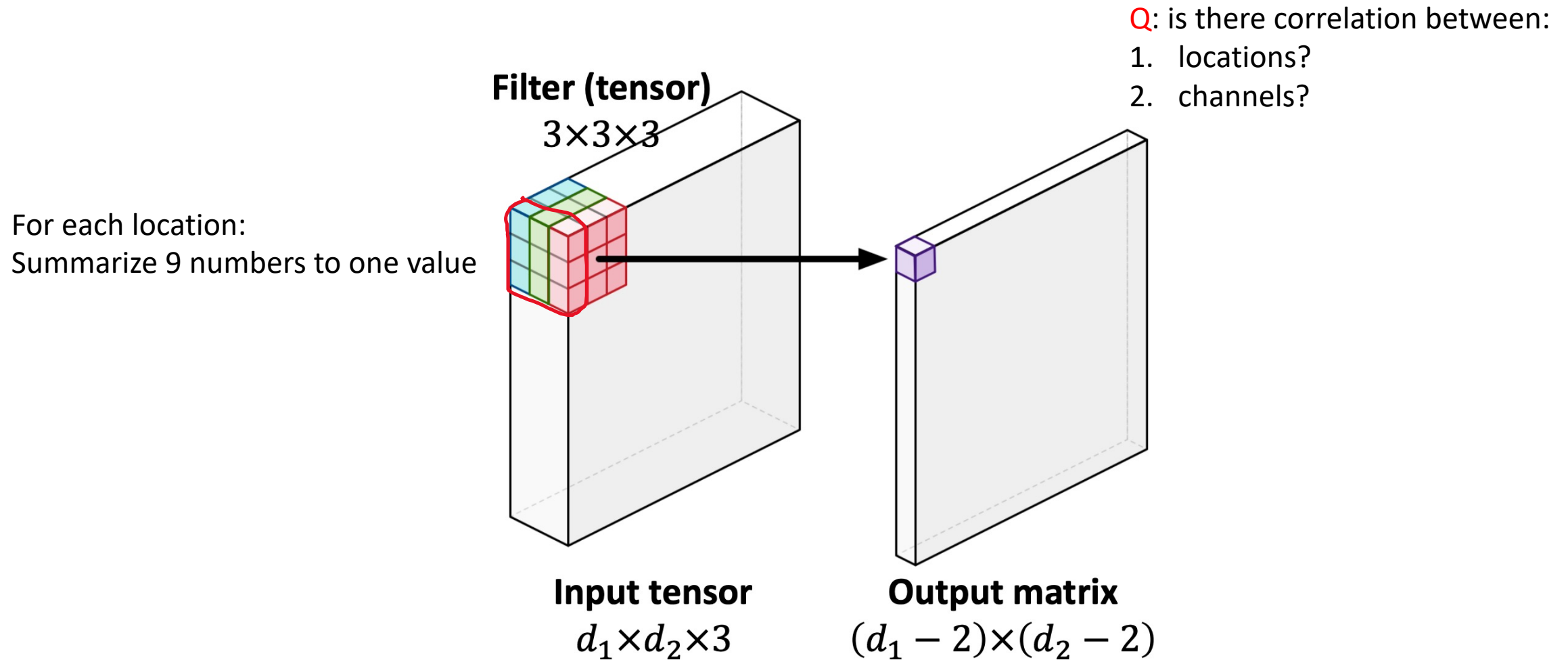
Correlation between data



Correlation between data



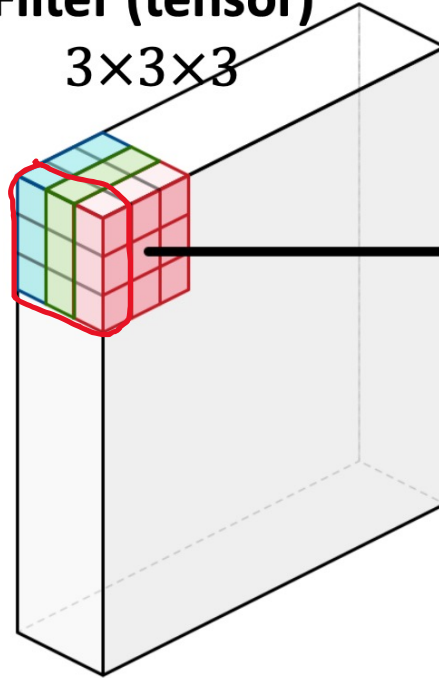
Correlation between data



Correlation between data

For each location:
Summarize 9 numbers to one value
(correlation among channels)

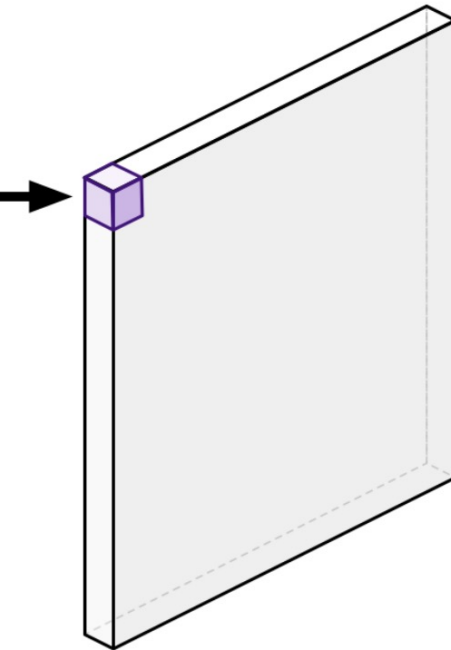
Filter (tensor)
 $3 \times 3 \times 3$



Input tensor
 $d_1 \times d_2 \times 3$

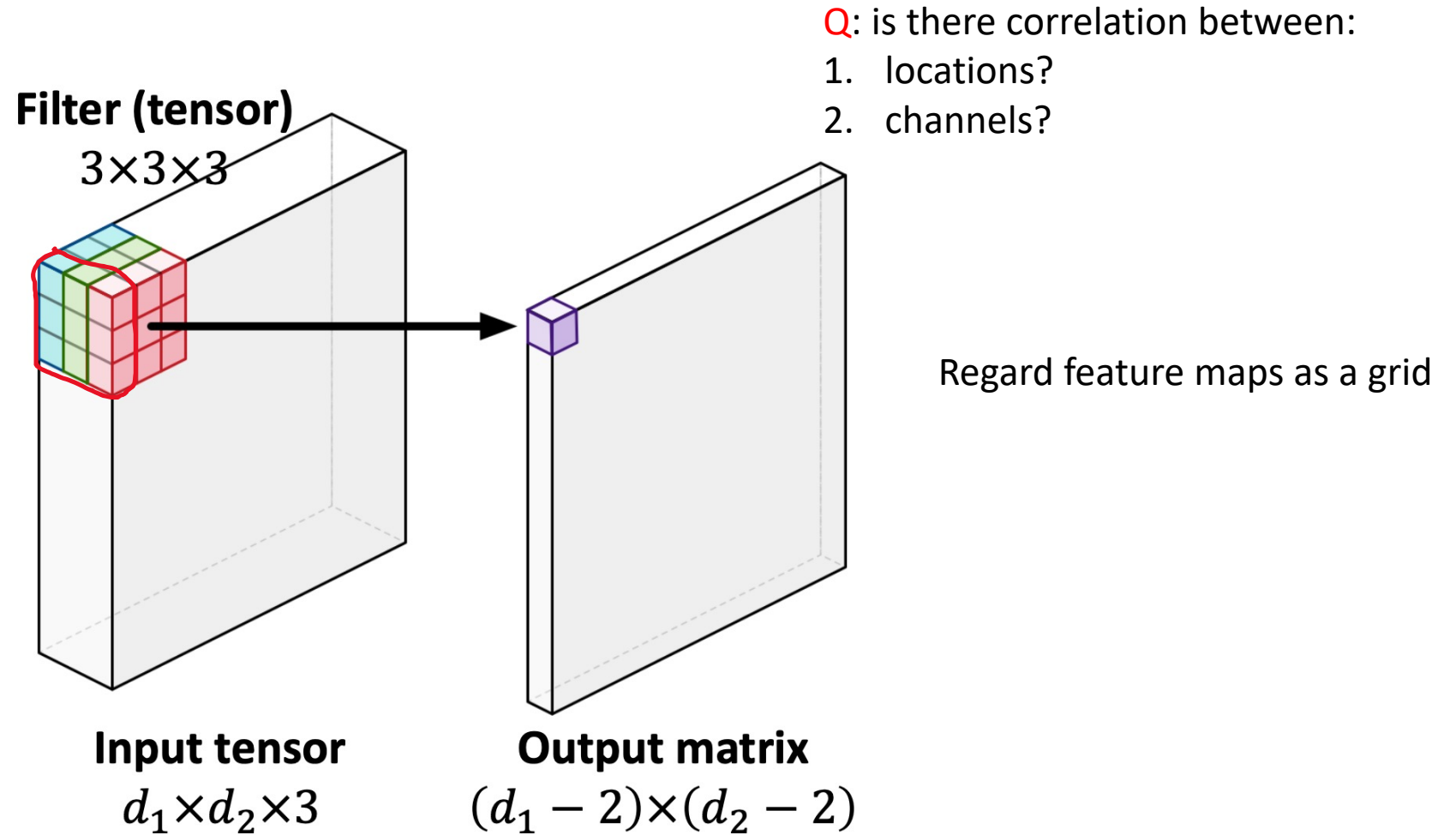
Q: is there correlation between:

1. locations?
2. channels?

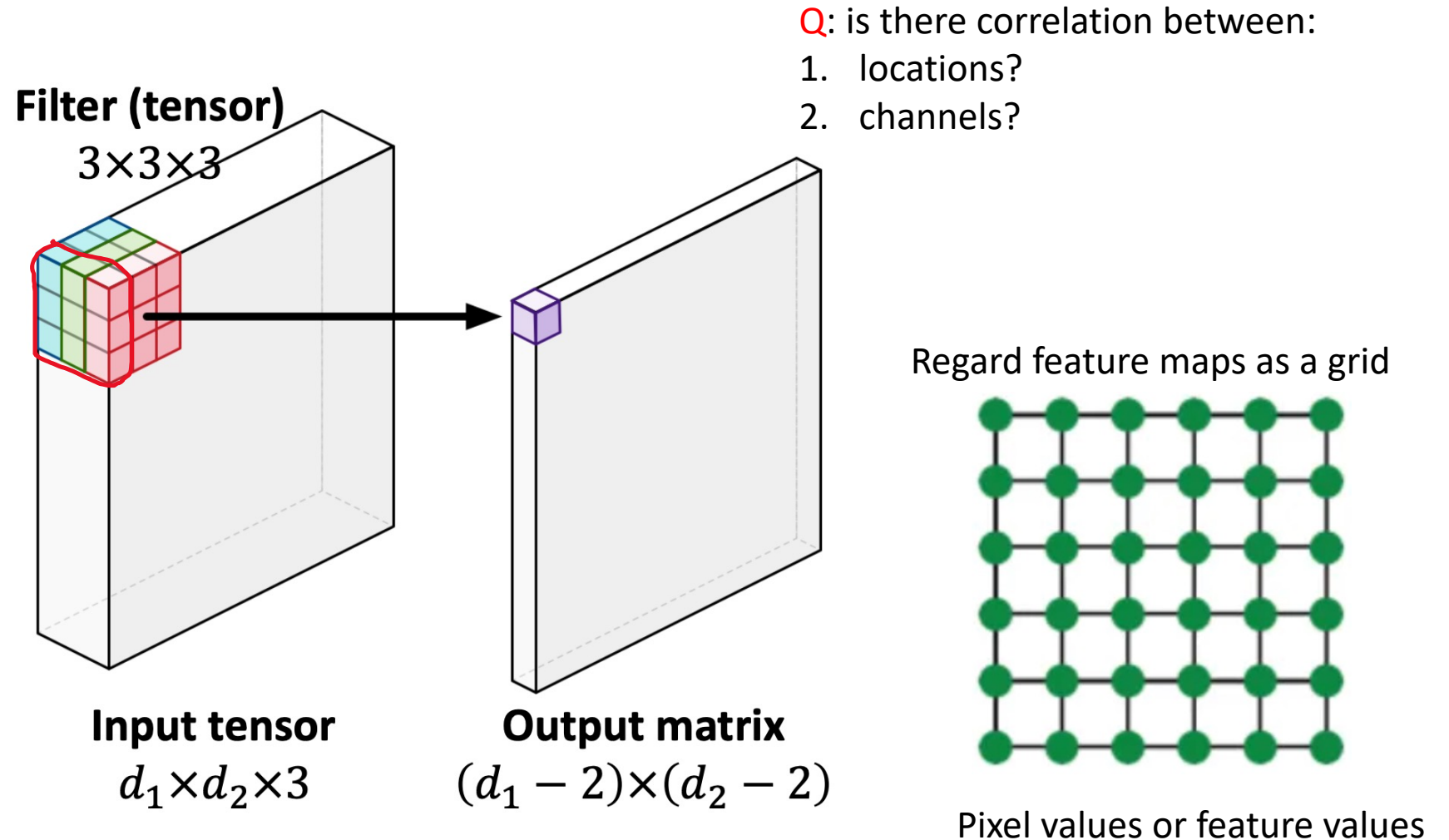


Output matrix
 $(d_1 - 2) \times (d_2 - 2)$

Correlation between data



Correlation between data



Correlation between data



Cat or dog?

Correlation between data



Cat or dog?

Q: is there correlation **between** images?

Correlation between data



Cat or dog?

Q: is there correlation **between images**?
No

Correlation between data

The diagram illustrates the incremental construction of a sentence, with each new word highlighted in red. Blue shaded regions around certain words indicate their correlation with previously processed words. The sequence of words is as follows:

- The
- The FBI
- The FBI is
- The FBI is chasing
- The FBI is chasing a
- The FBI is chasing a criminal
- The FBI is chasing a criminal on
- The FBI is chasing a criminal on the
- The FBI is chasing a criminal on the run
- The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

Correlation between data

The diagram illustrates the incremental construction of a sentence. Each line shows a new word being added to the previous line. Words are highlighted in blue when they are part of the current context and in red when they are newly added. The final line, "The FBI is chasing a criminal on the run .", is enclosed in a red rectangular box.

The
The FBI
The FBI is
The FBI is chasing
The FBI is chasing a
The FBI is chasing a criminal
The FBI is chasing a criminal on
The FBI is chasing a criminal on the
The FBI is chasing a criminal on the run
The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

Correlation between data

The diagram illustrates the incremental construction of a sentence. It consists of ten lines of text, each showing a different stage of the sentence being built. Words are highlighted in blue to show the current state of the model's prediction. The final sentence is "The FBI is chasing a criminal on the run .". The first three words "The FBI is" are enclosed in a red rectangular box, indicating the current state of the model's prediction.

The
The FBI
The FBI is
The FBI is chasing
The FBI is chasing a
The FBI is chasing a criminal
The FBI is chasing a criminal on
The FBI is chasing a criminal on the
The FBI is chasing a criminal on the run
The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

The FBI is

Correlation between data

The
The FBI
The FBI is
The FBI is chasing
The FBI is chasing a
The FBI is chasing a criminal
The FBI is chasing a criminal on
The FBI is chasing a criminal on the
The FBI is chasing a criminal on the run
The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

The FBI is

FBI is chasings

Correlation between data

The
The FBI
The FBI is
The FBI is chasing
The FBI is chasing a
The FBI is chasing a criminal
The FBI is chasing a criminal on
The FBI is chasing a criminal on the
The FBI is chasing a criminal on the run
The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

The FBI is

FBI is chasings

Correlation between data

The
The FBI
The FBI is
The FBI is chasing
The FBI is chasing a
The FBI is chasing a criminal
The FBI is chasing a criminal on
The FBI is chasing a criminal on the
The FBI is chasing a criminal on the run
The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

The FBI is

FBI is chasings

Sequence data



Correlation between data

The
The FBI
The FBI is
The FBI is chasing
The FBI is chasing a
The FBI is chasing a criminal
The FBI is chasing a criminal on
The FBI is chasing a criminal on the
The FBI is chasing a criminal on the run
The FBI is chasing a criminal on the run .

Figure is from the paper "Long Short-Term Memory-Networks for Machine Reading."

The FBI is

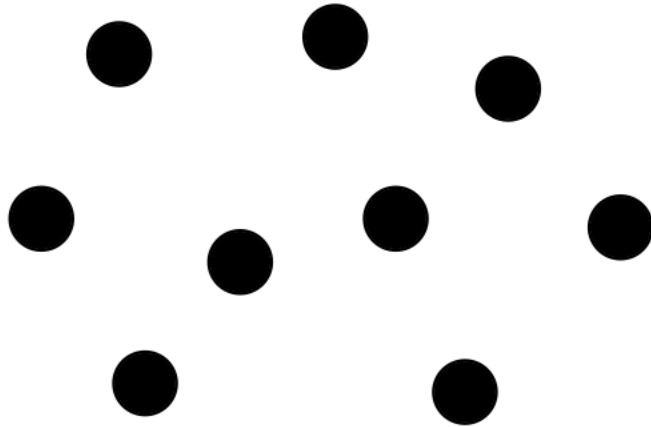
FBI is chasings

Sequence data

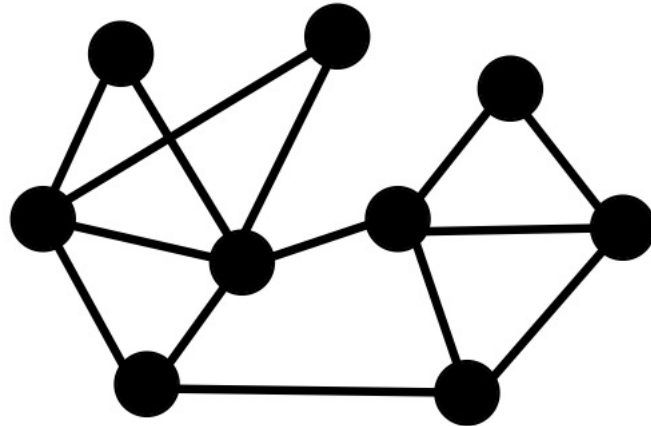


Q: what if we need more complicated correlation?

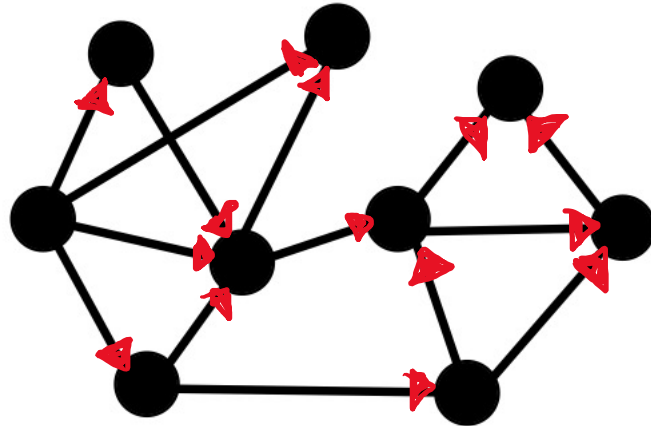
Correlation between data



Correlation between data

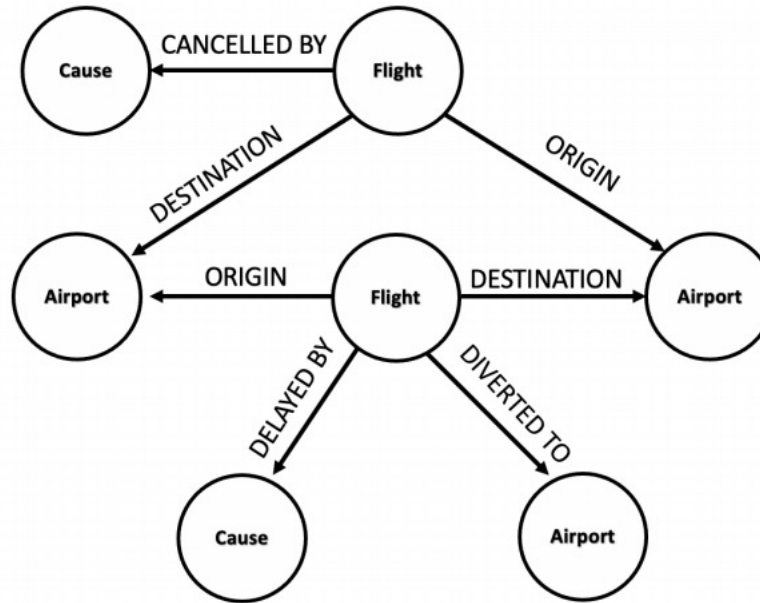


Correlation between data



(with directions)

Correlation between data



Event Graphs

Correlation between data



Image credit: [SalientNetworks](#)

Computer Networks

Correlation between data

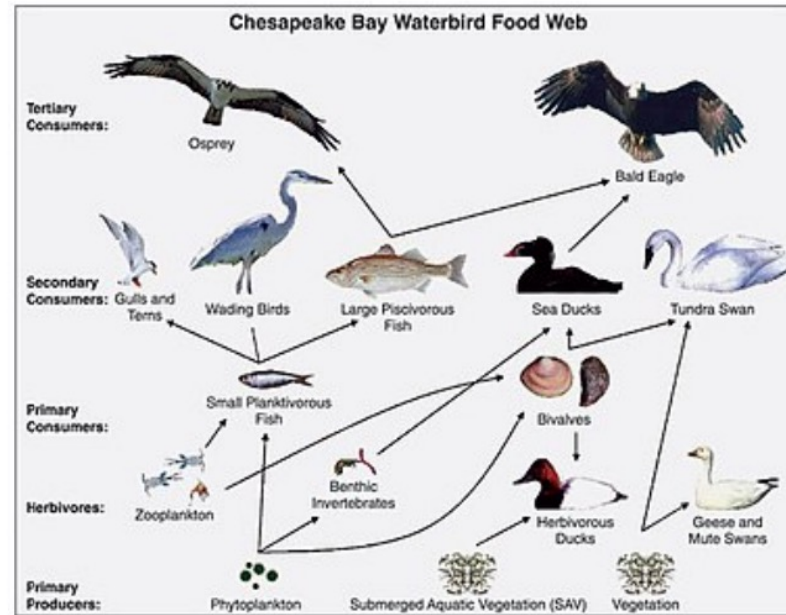


Image credit: [Wikipedia](#)

Food Webs

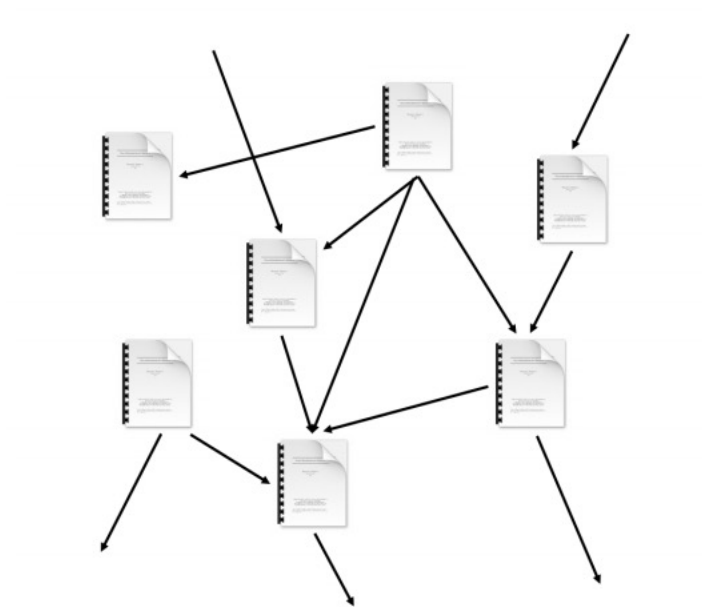
Correlation between data



Image credit: Medium

Social Networks

Correlation between data



Citation Networks

Correlation between data

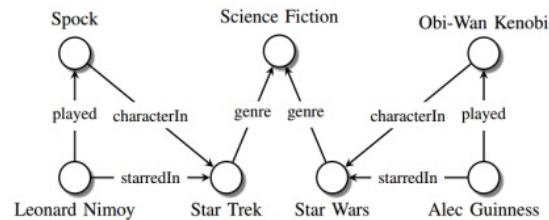


Image credit: [Maximilian Nickel et al](#)

Knowledge Graphs

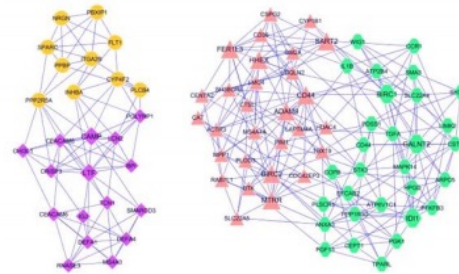


Image credit: [ese.wustl.edu](#)

Regulatory Networks

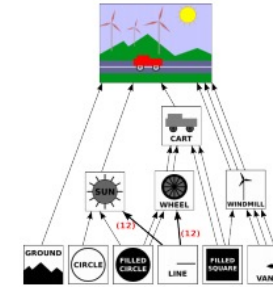


Image credit: [math.hws.edu](#)

Scene Graphs

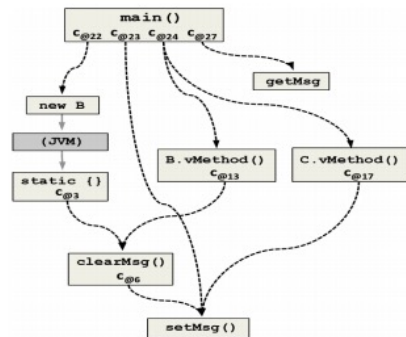


Image credit: [ResearchGate](#)

Code Graphs

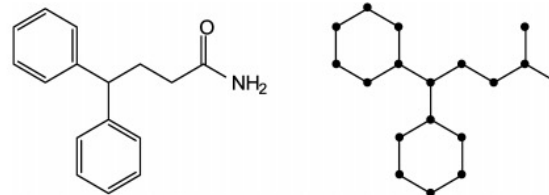


Image credit: [MDPI](#)

Molecules

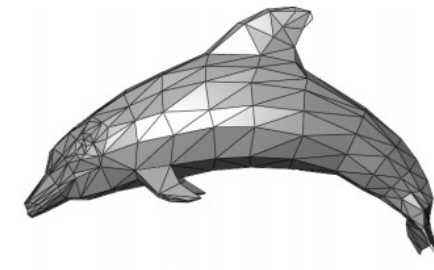
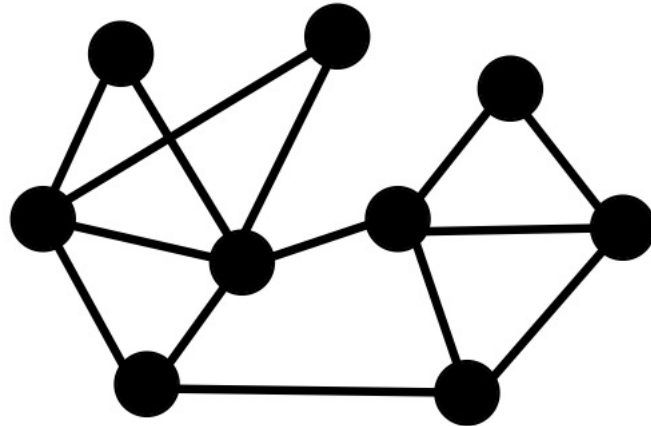


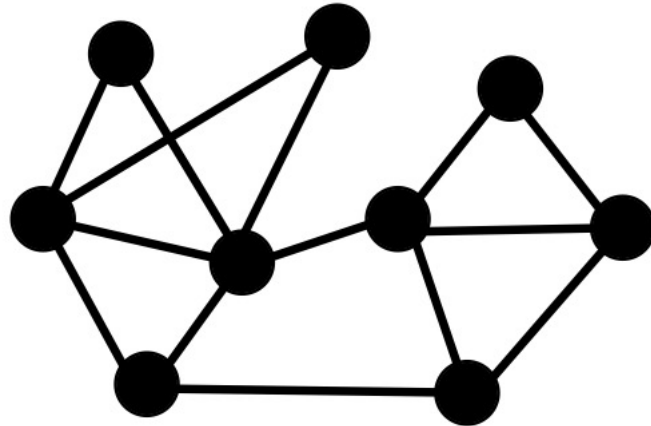
Image credit: [Wikipedia](#)

3D Shapes

Correlation between data

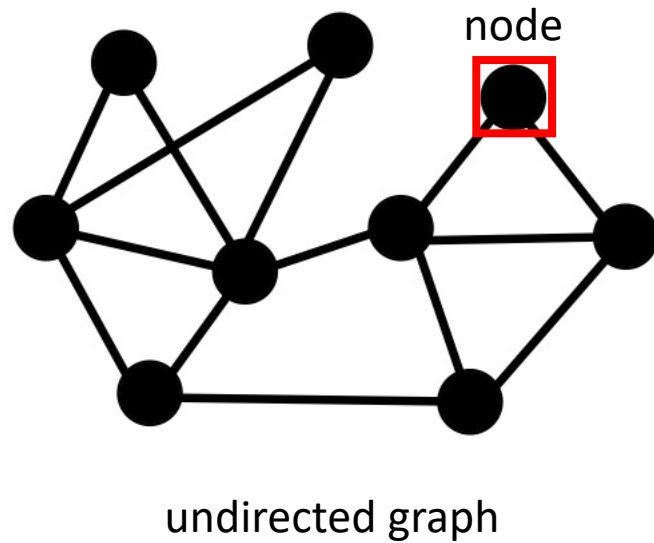


Correlation between data

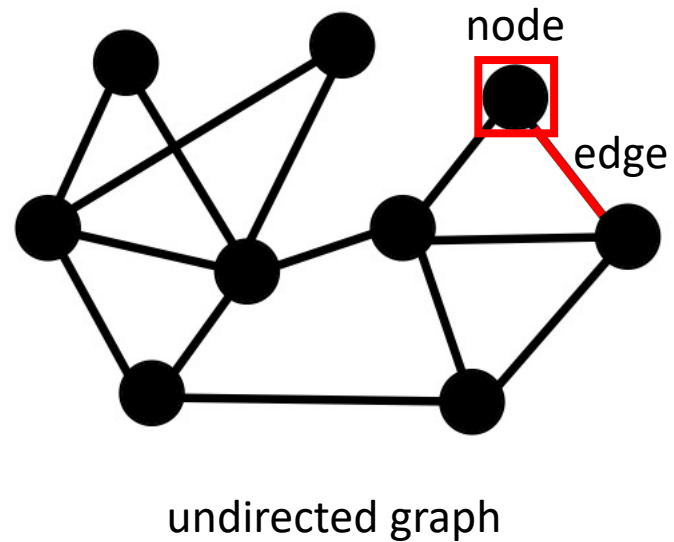


undirected graph

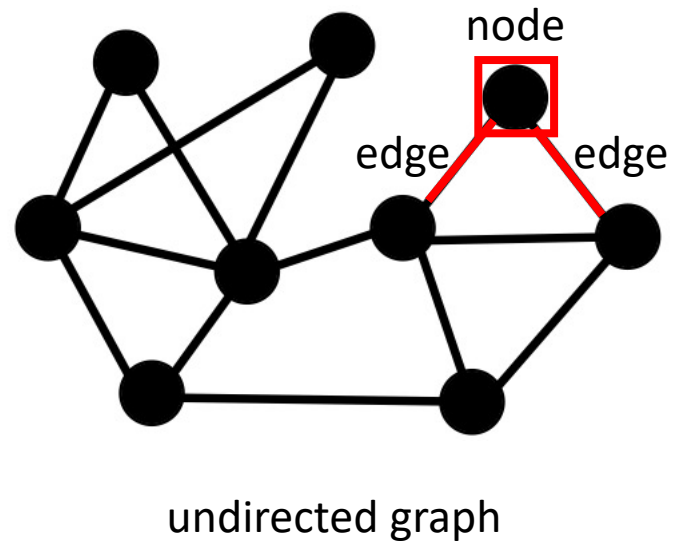
Correlation between data



Correlation between data

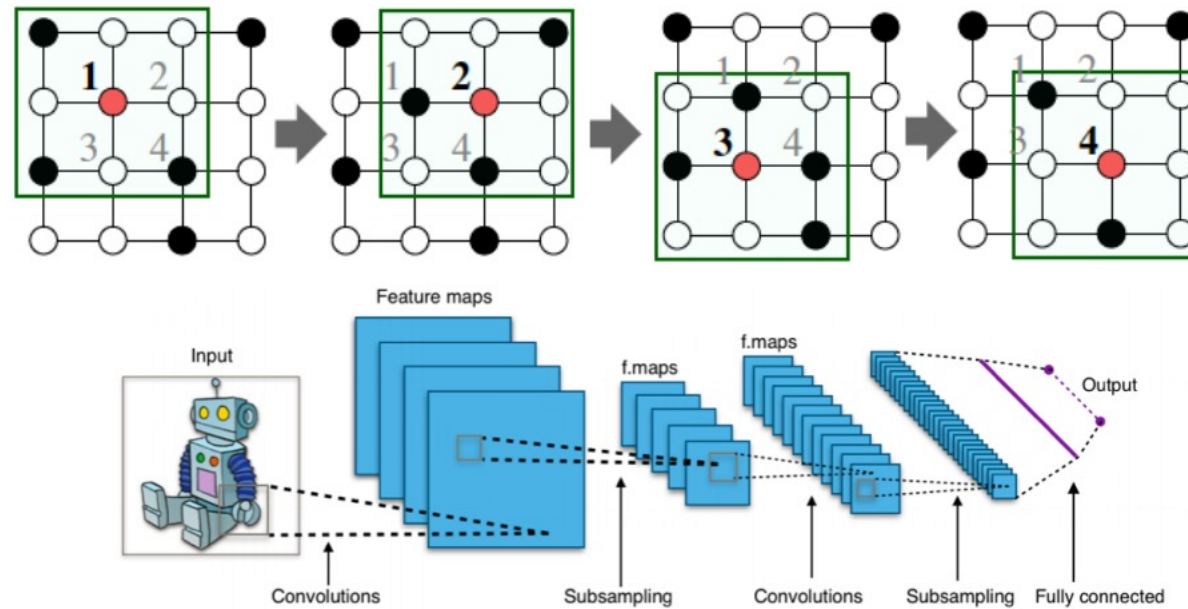


Correlation between data



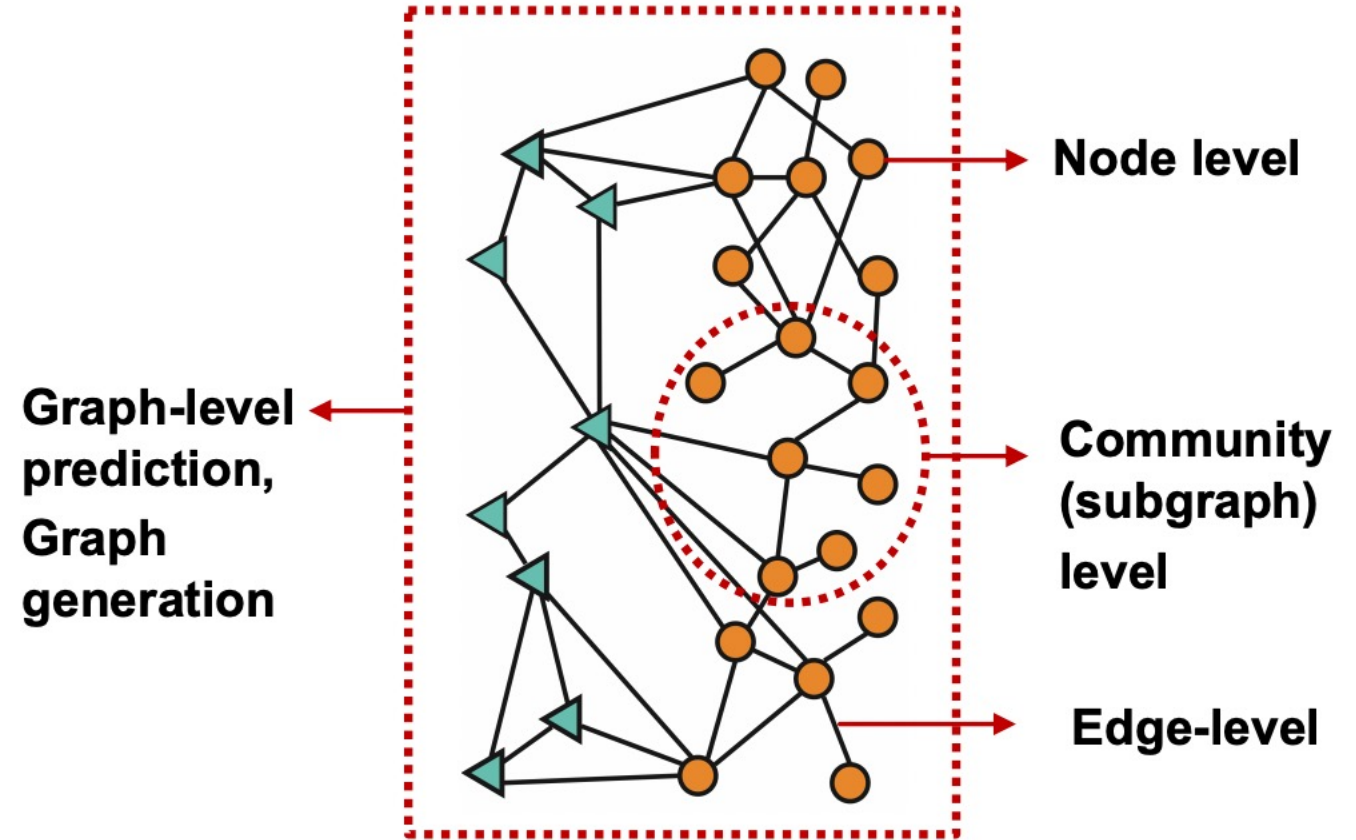
Correlation between data

CNN on an image:



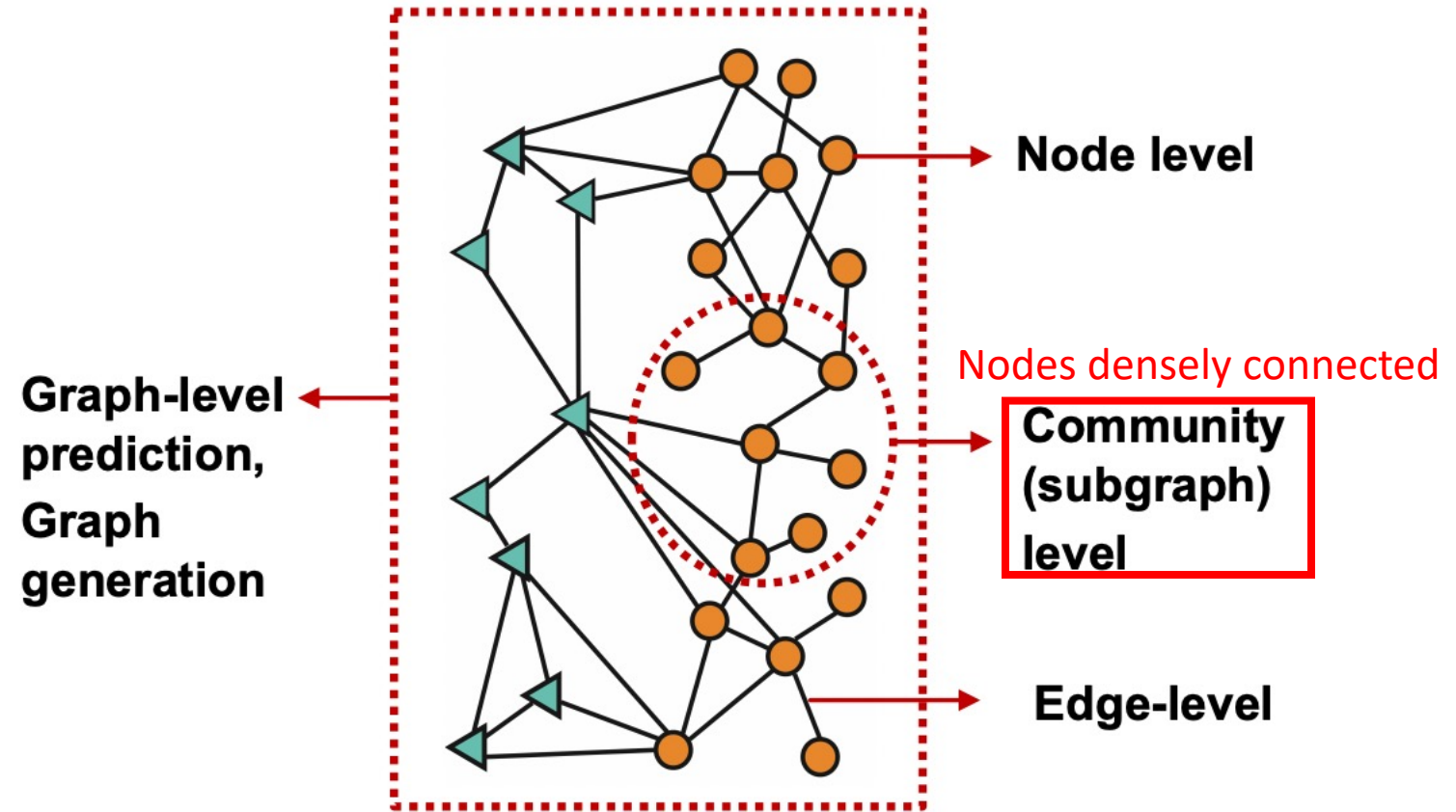
Machine learning tasks for graph data

- Node level
- Edge level
- Community level
- Graph level



Machine learning tasks for graph data

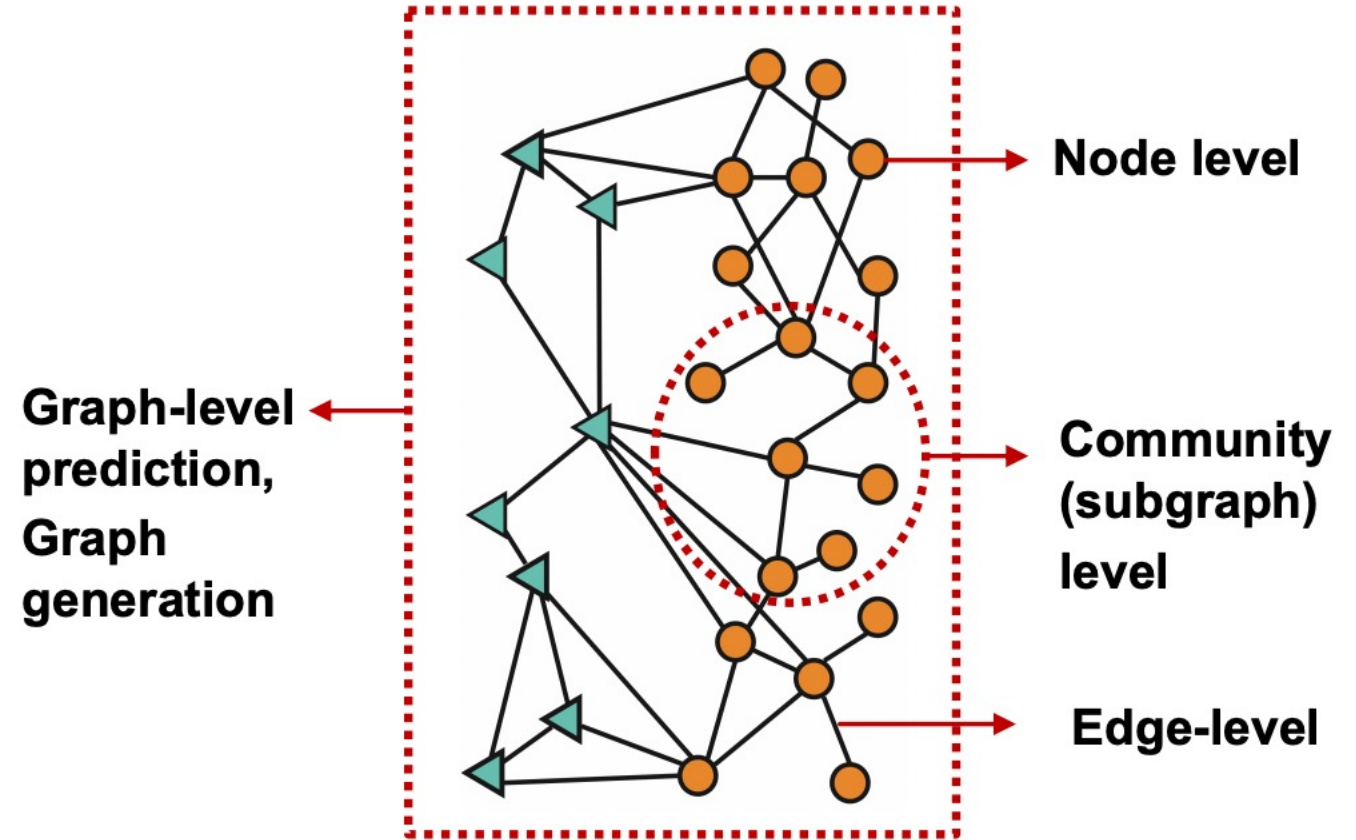
- Node level
- Edge level
- Community level
- Graph level



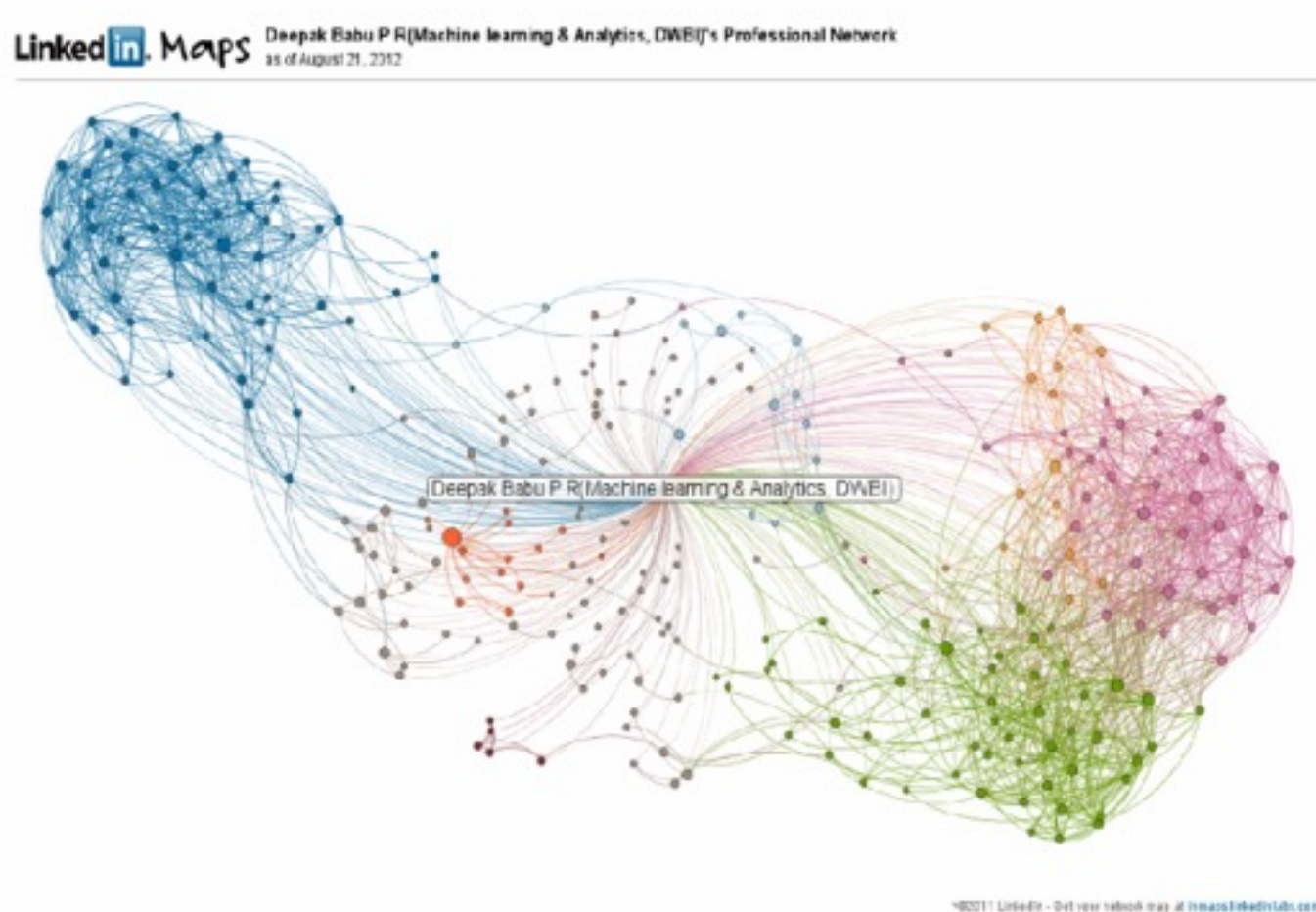
Machine learning tasks for graph data

classification

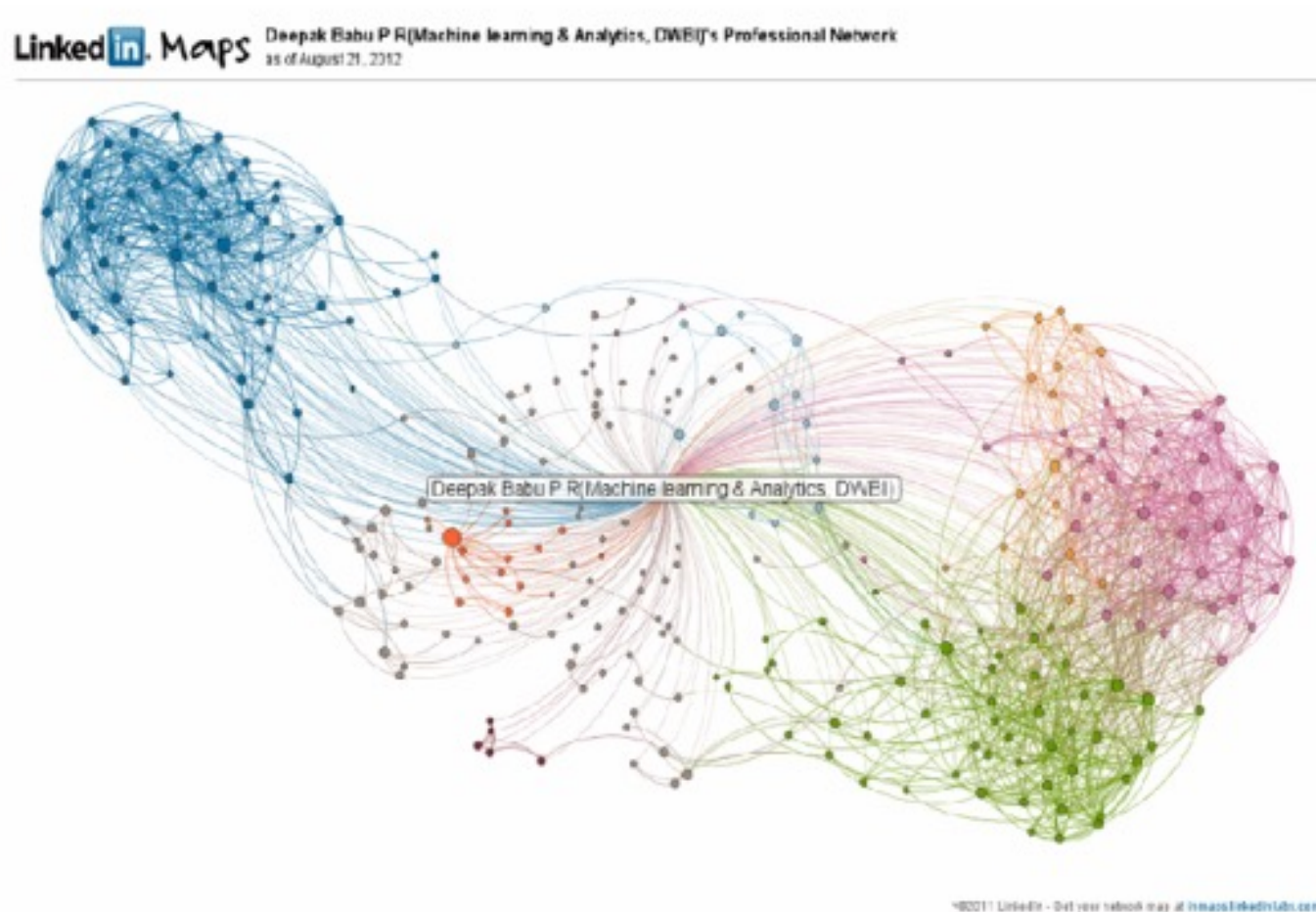
- Node level
- Edge level
- Community level
- Graph level



Social network

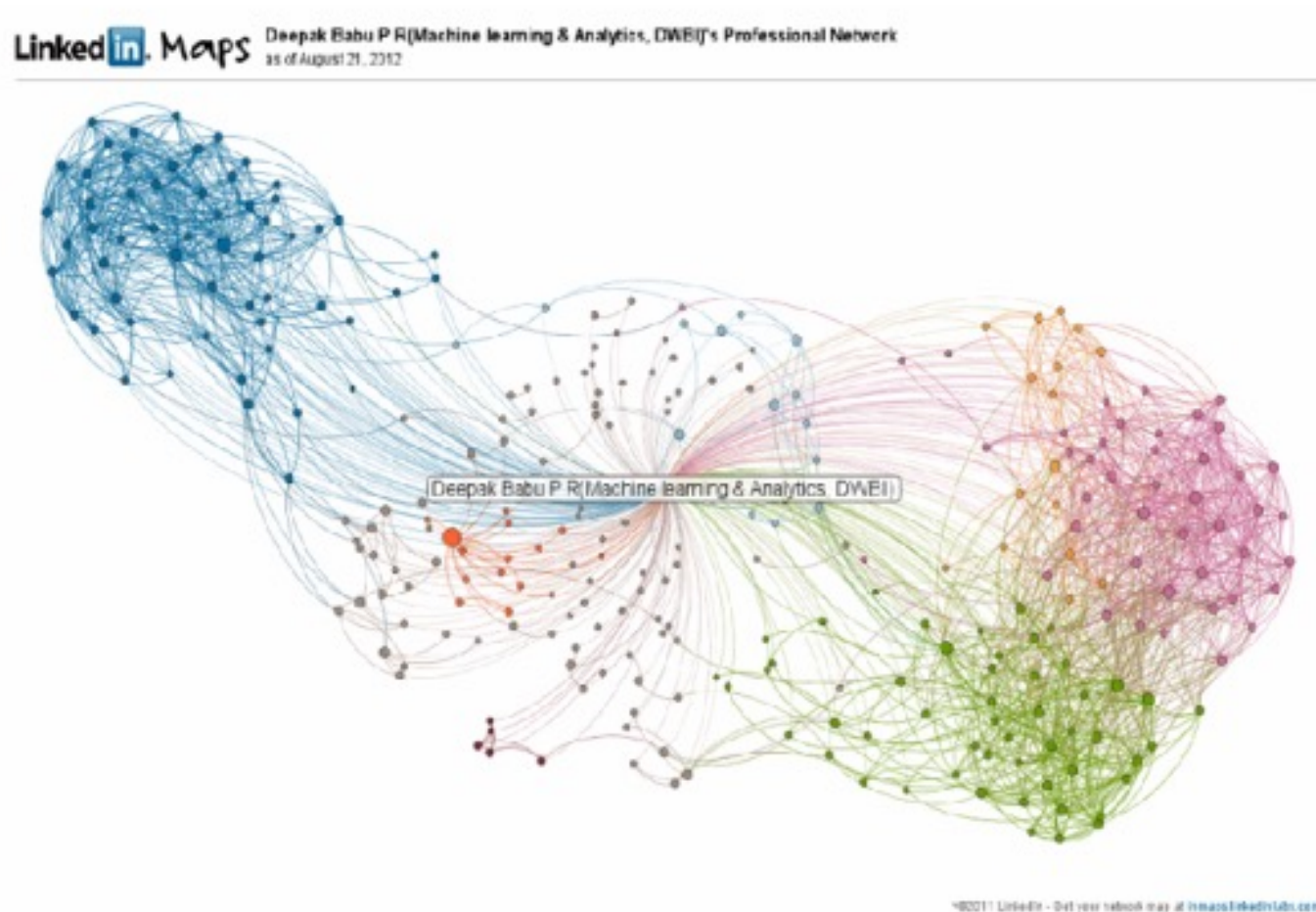


Social network



Nodes: users

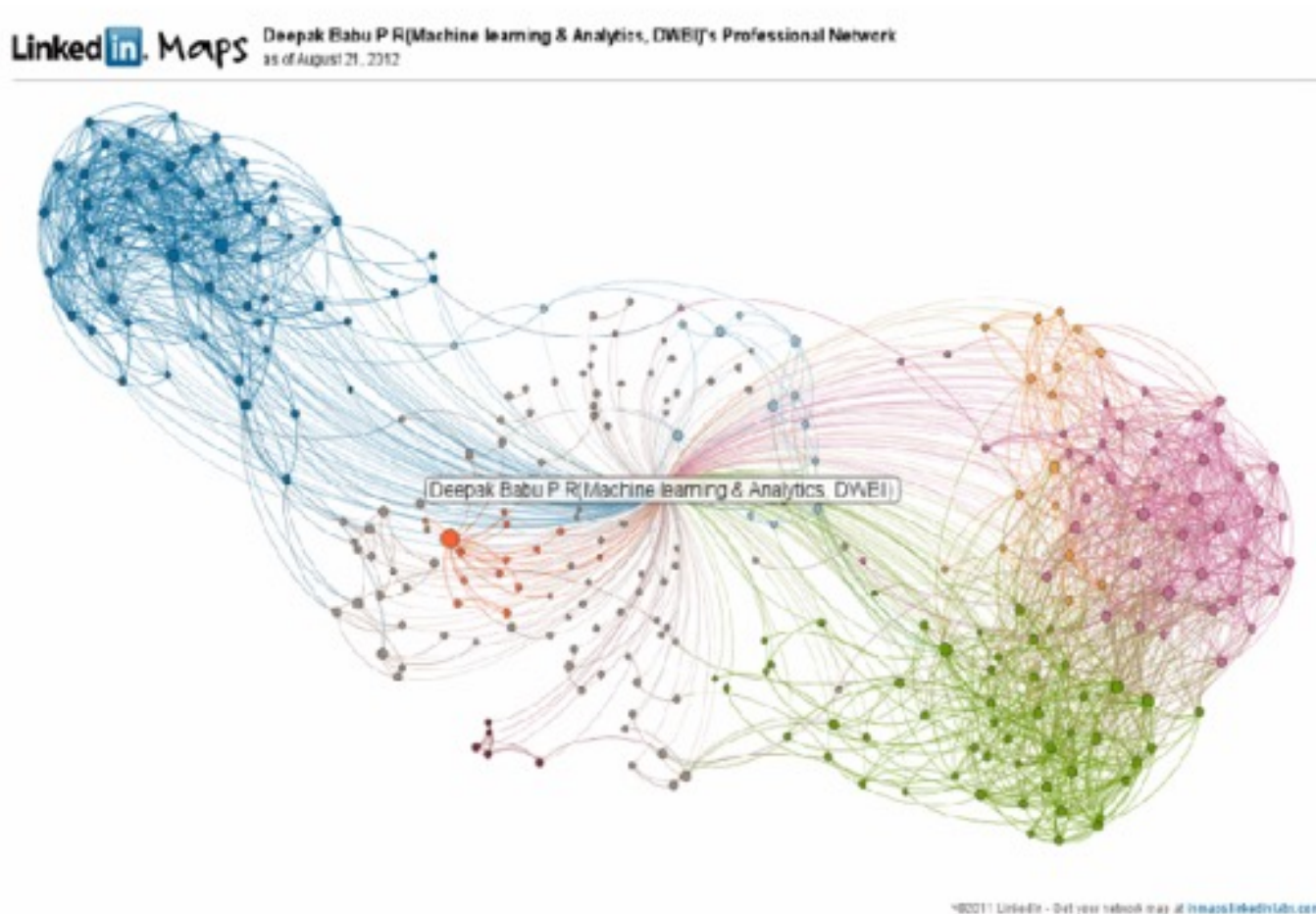
Social network



Nodes: users

Edges: interactions

Social network

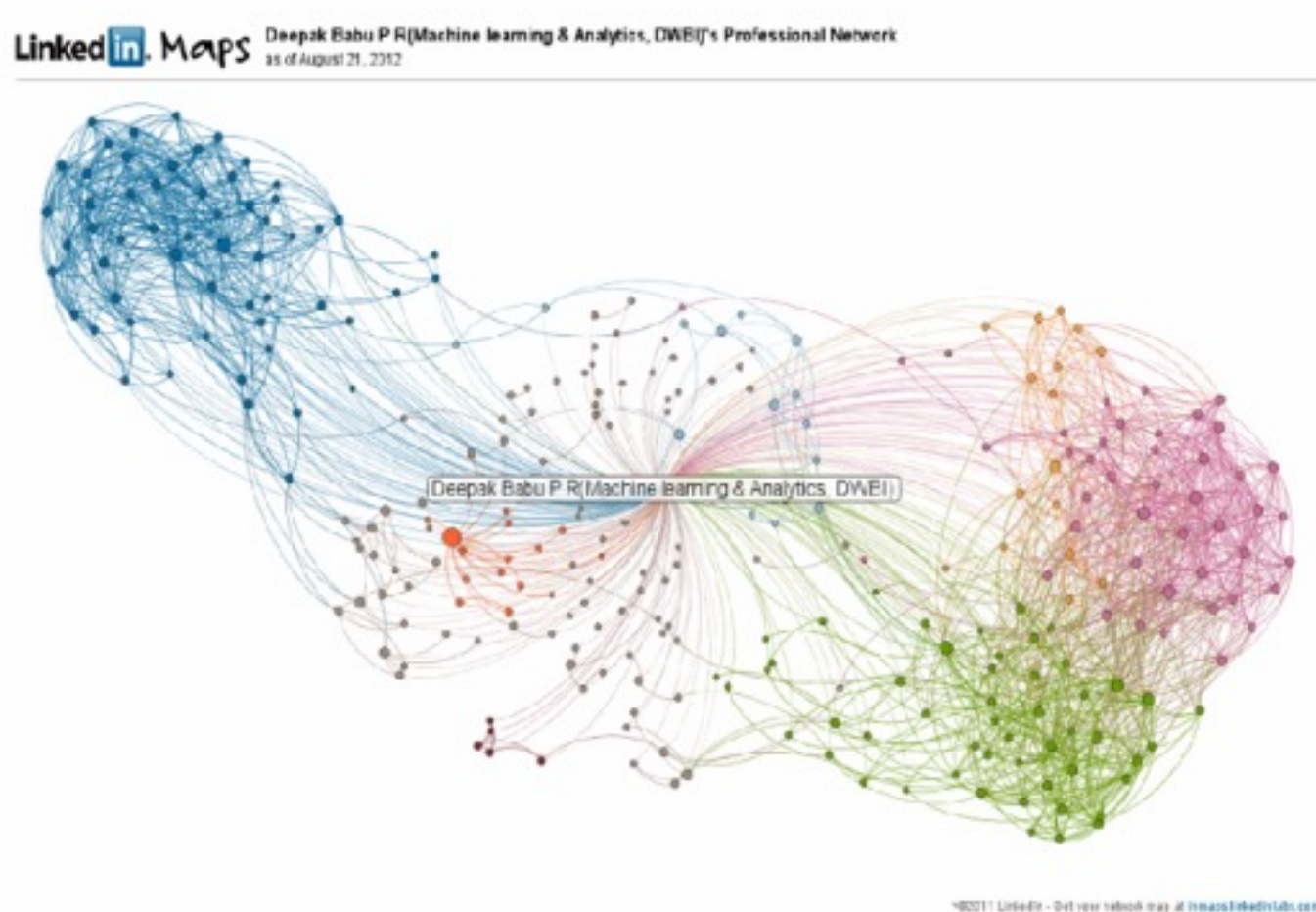


Nodes: users

Edges: interactions

FB: add friend

Social network

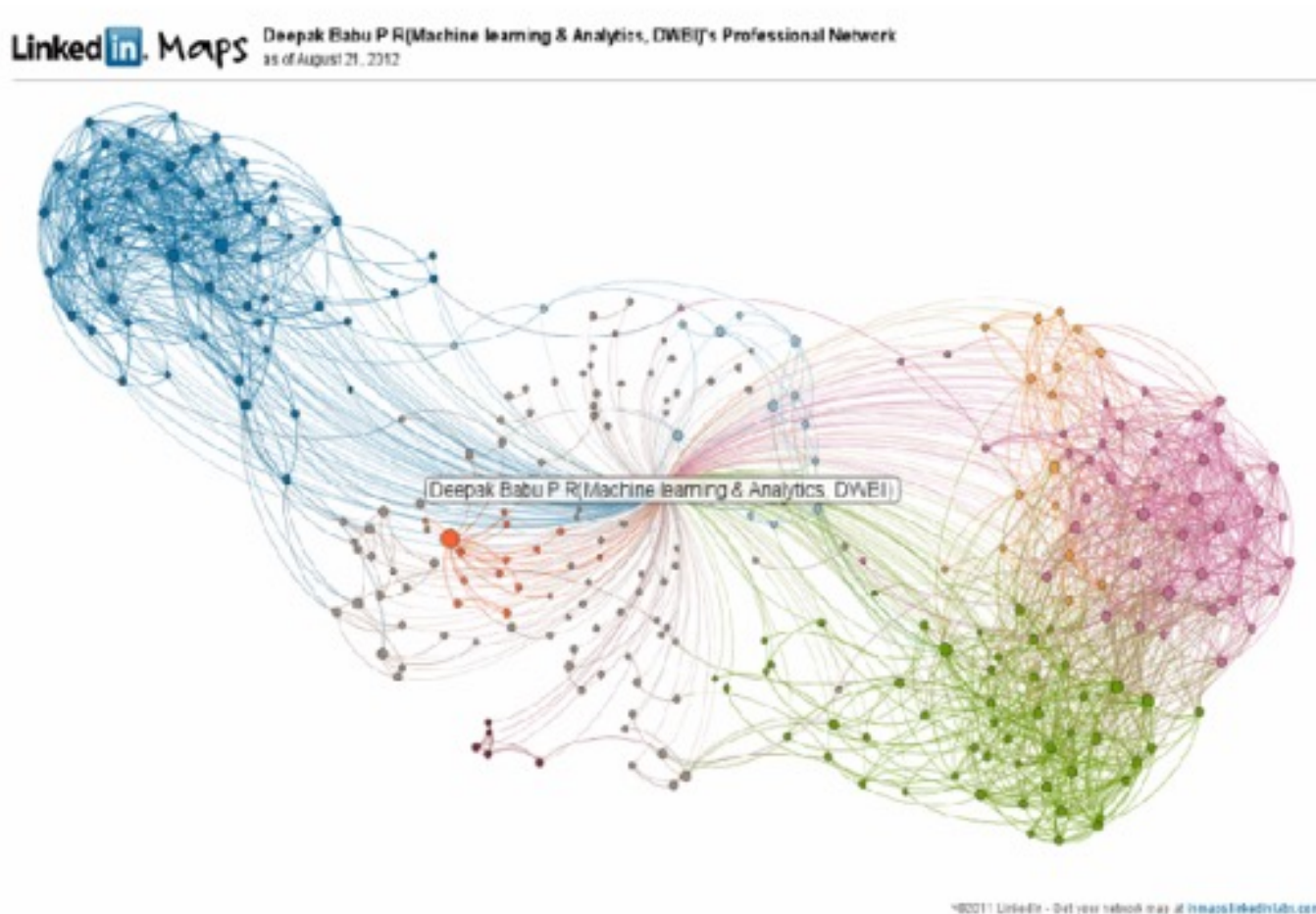


Nodes: users

Edges: interactions

LinkedIn: connect

Social network

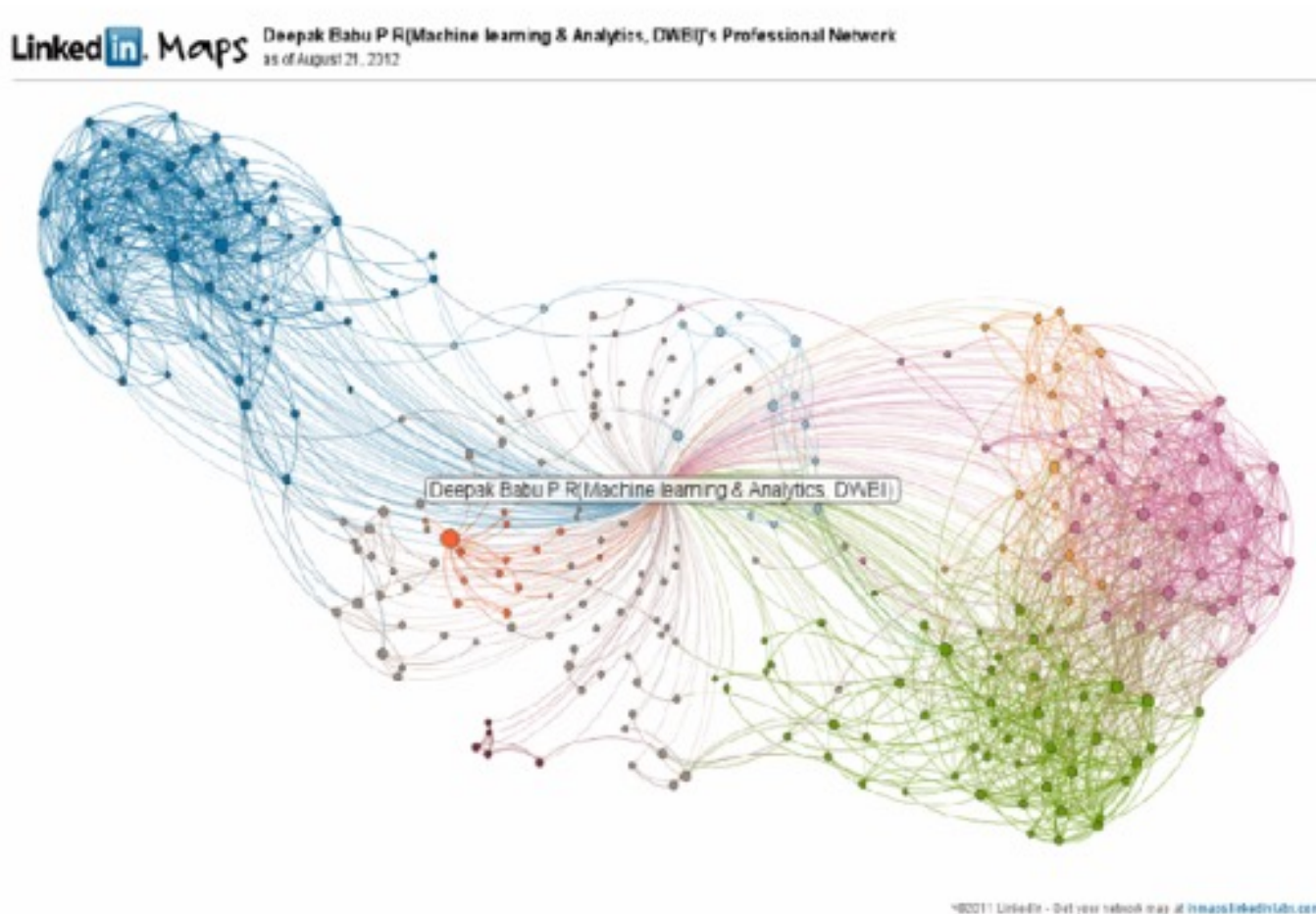


Nodes: users

Edges: interactions

Amazon: same purchase

Social network



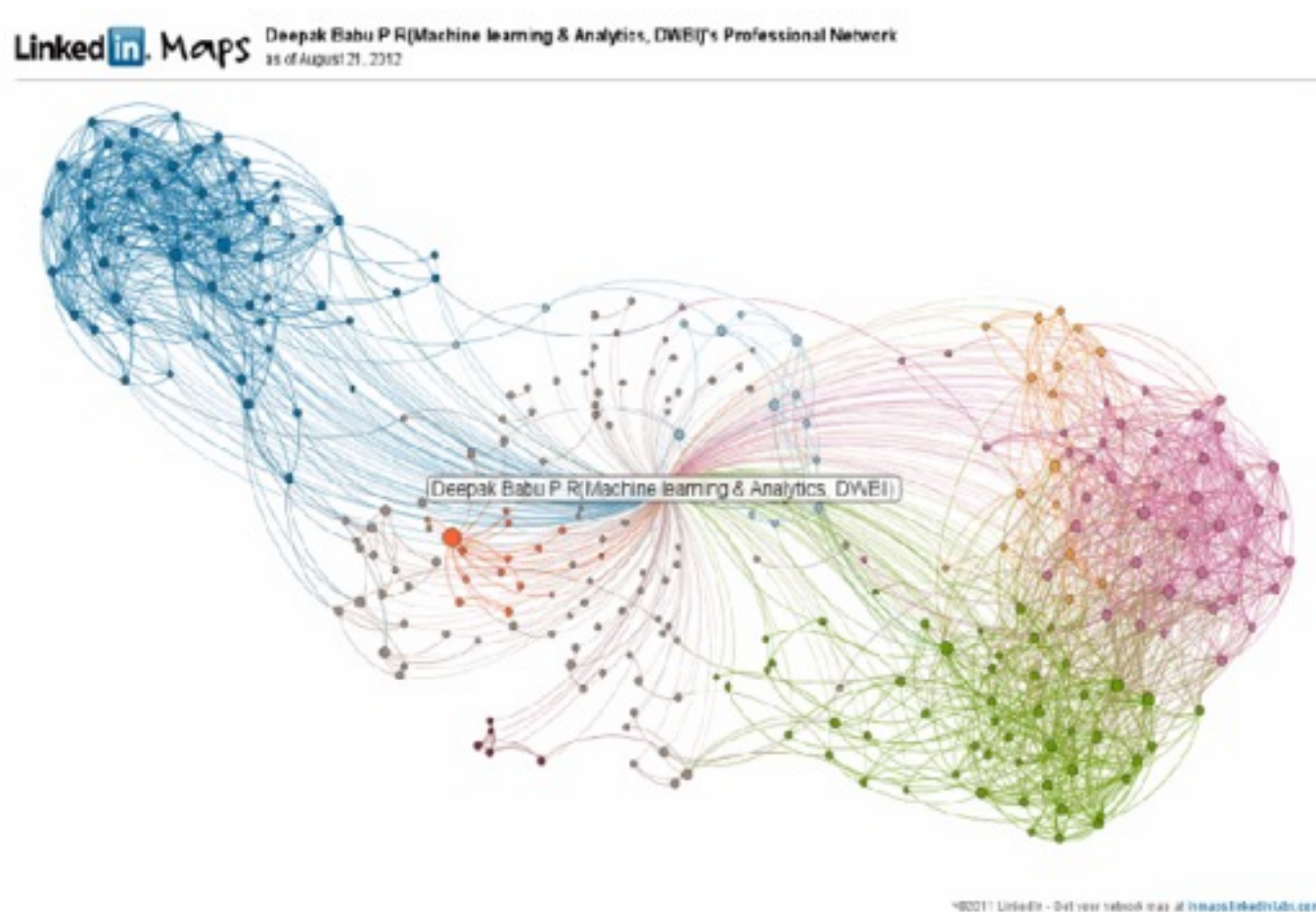
Nodes: users

Edges: interactions

Node classification:

Group nodes by their properties

Social network



Nodes: users

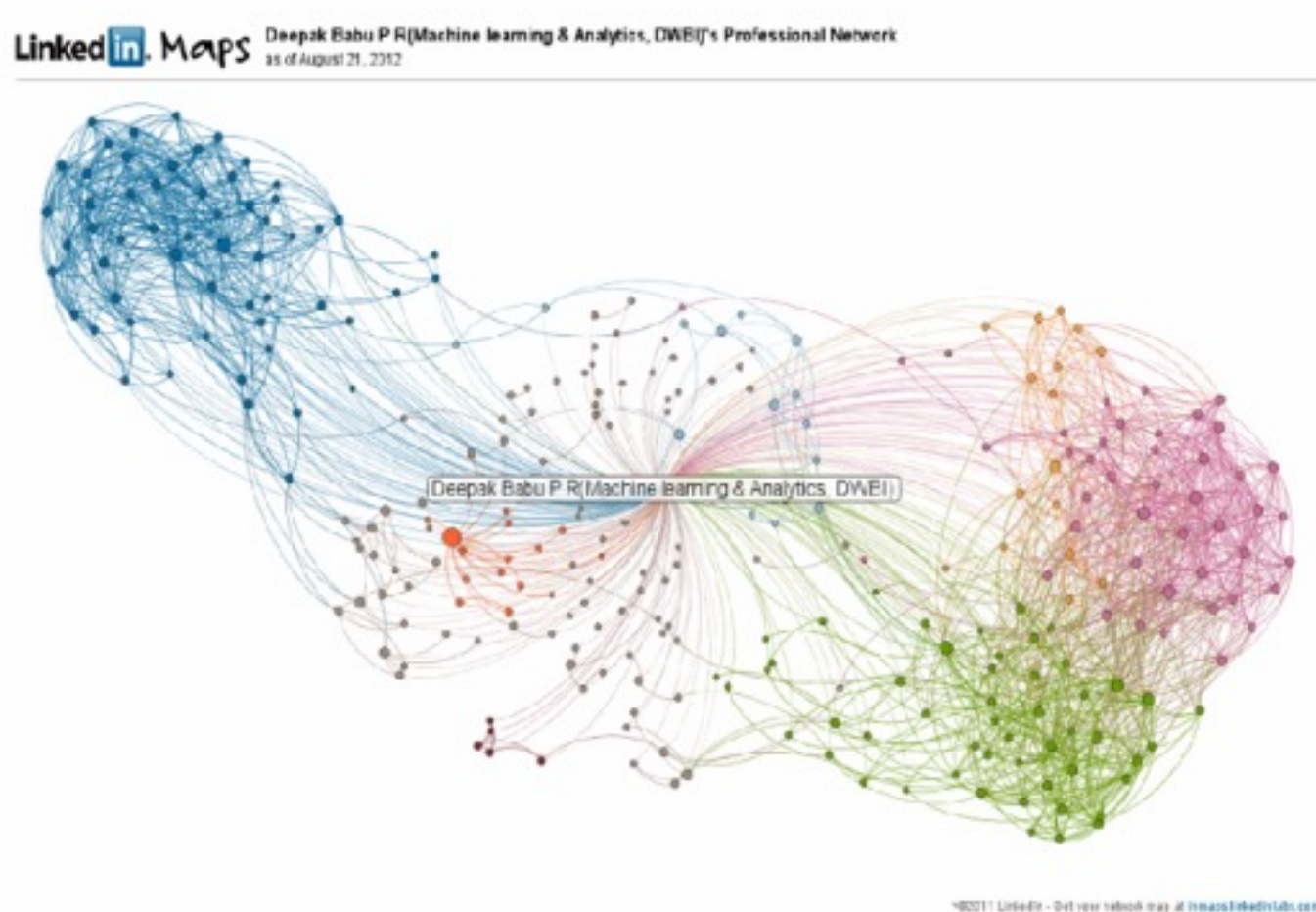
Edges: interactions

Edge classification:

Predict whether there are missing links
between two nodes

e.g., friend recommendation

Social network

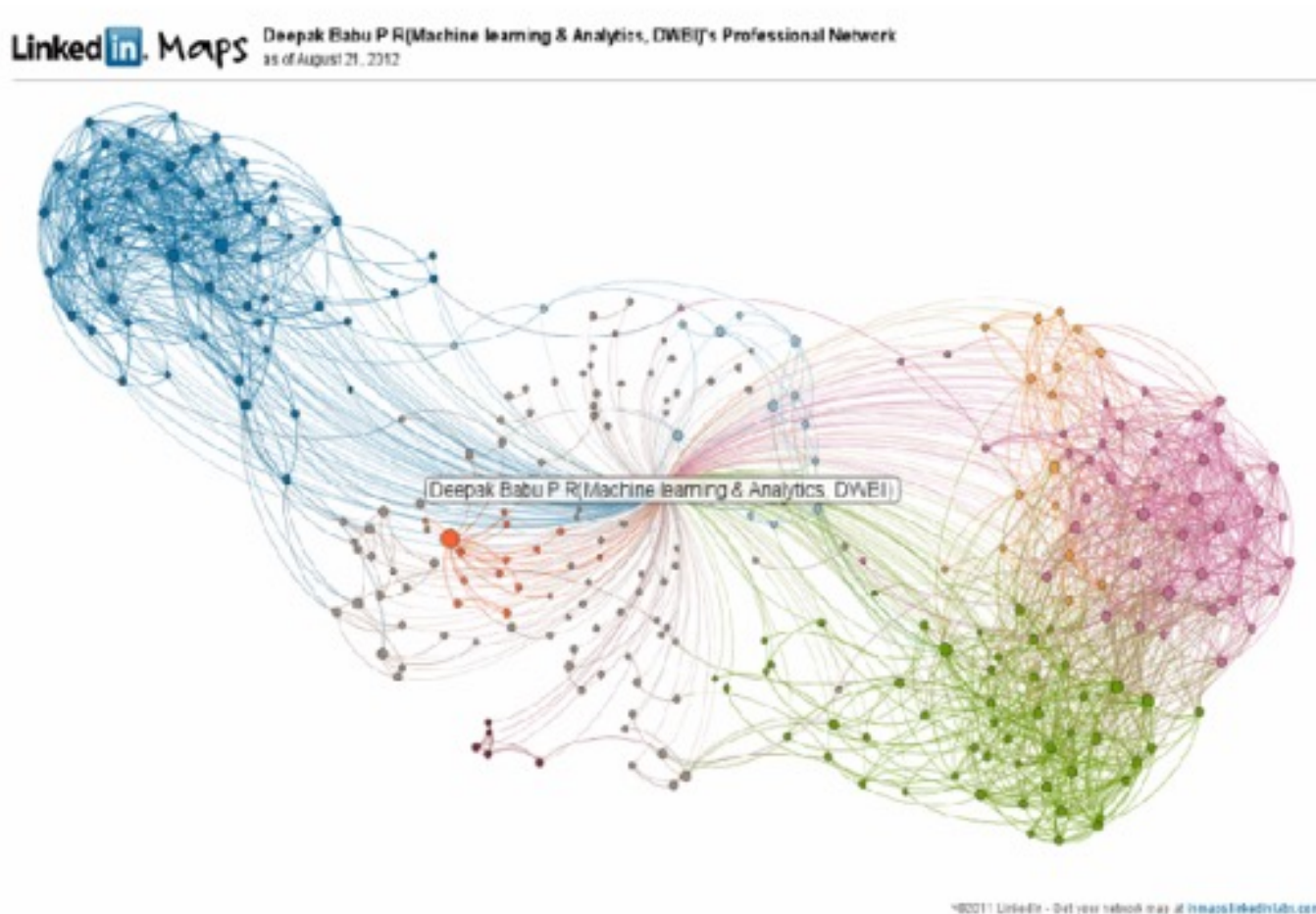


Nodes: users

Edges: interactions

Community detection:
Discover and group nodes tightly
connected

Social network



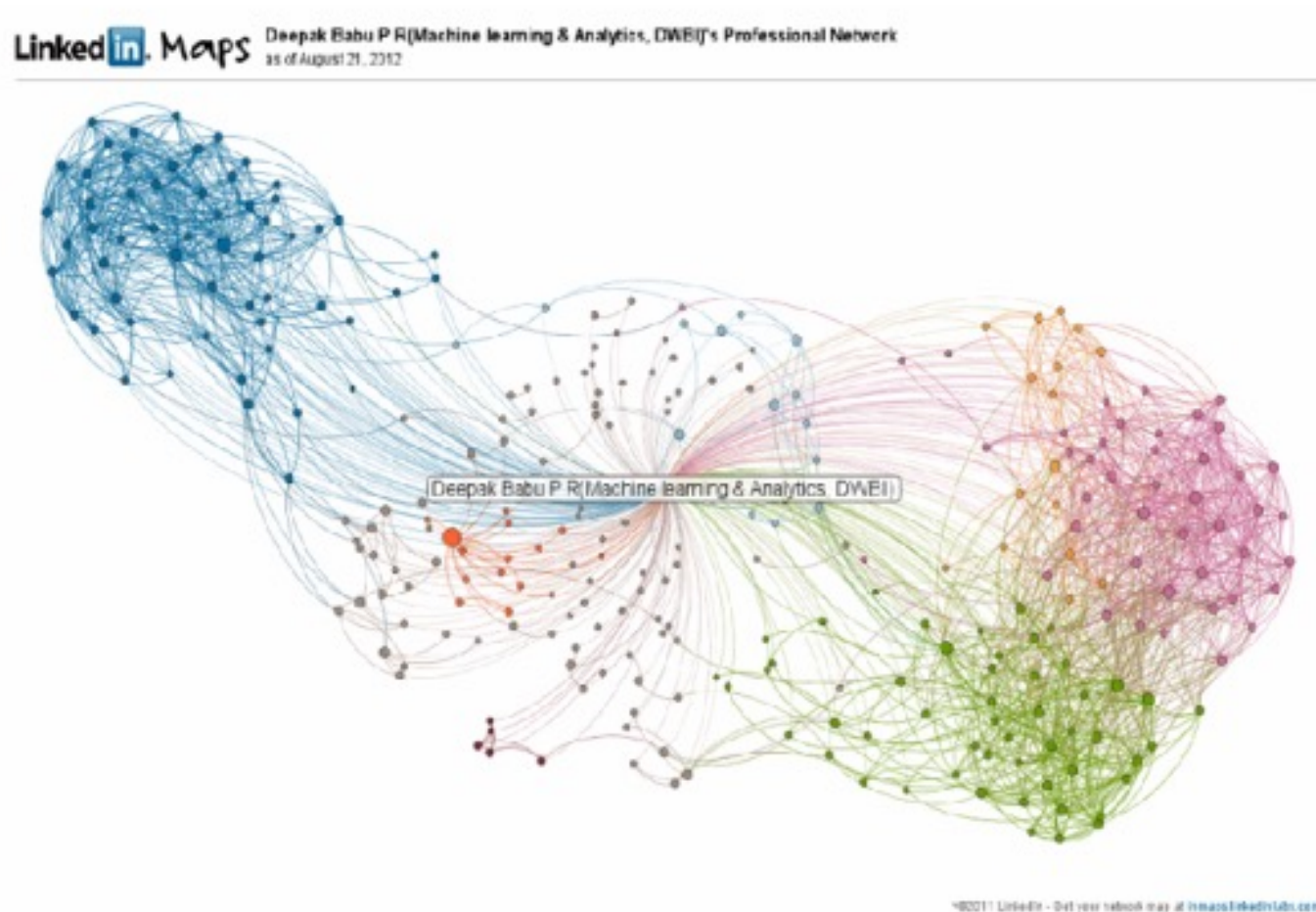
Nodes: users

Edges: interactions

Graph classification:

Categorize different graphs

Social network

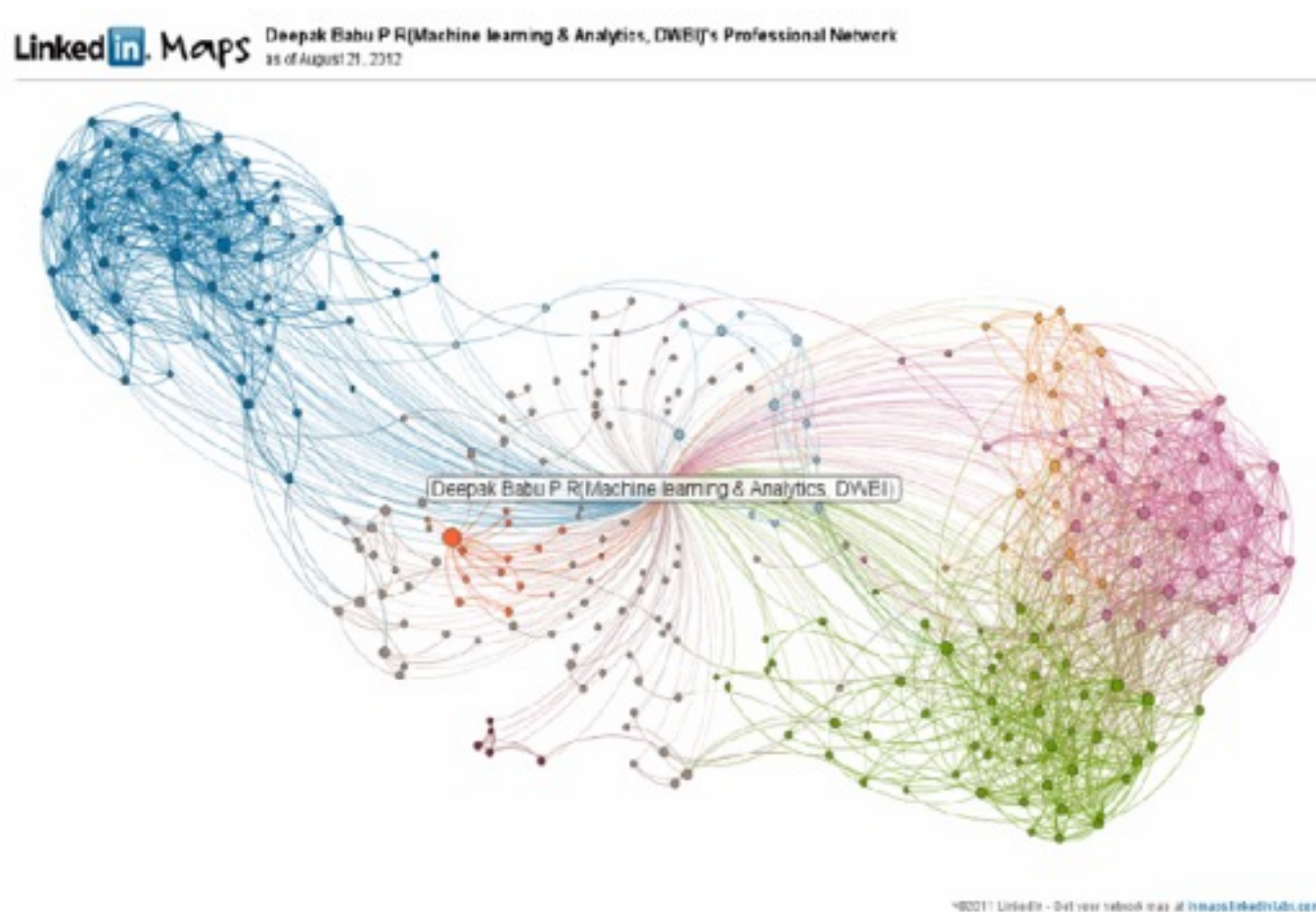


Nodes: users

Edges: interactions

Graph classification:
Categorize different graphs
e.g., Molecule property
prediction

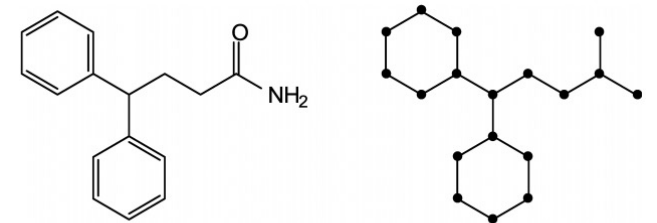
Social network



Nodes: users

Edges: interactions

Graph classification:
Categorize different graphs
e.g., Molecule property
prediction

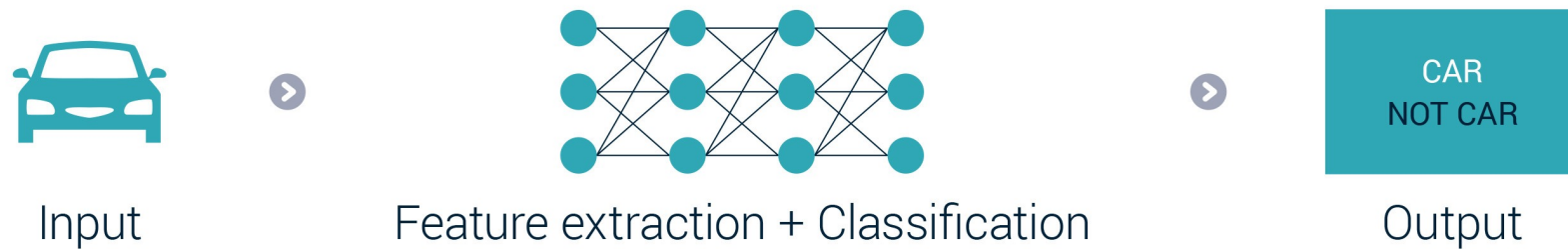


Machine learning tasks for graph data

Machine Learning

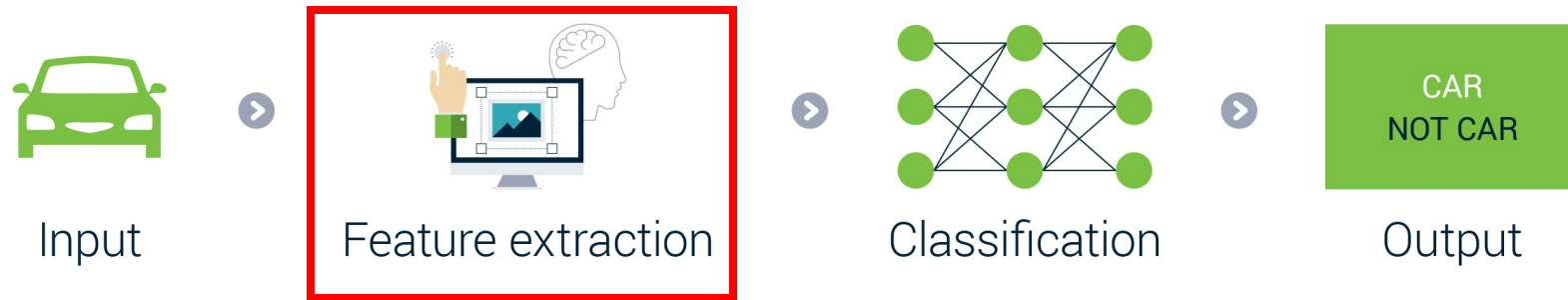


Deep Learning

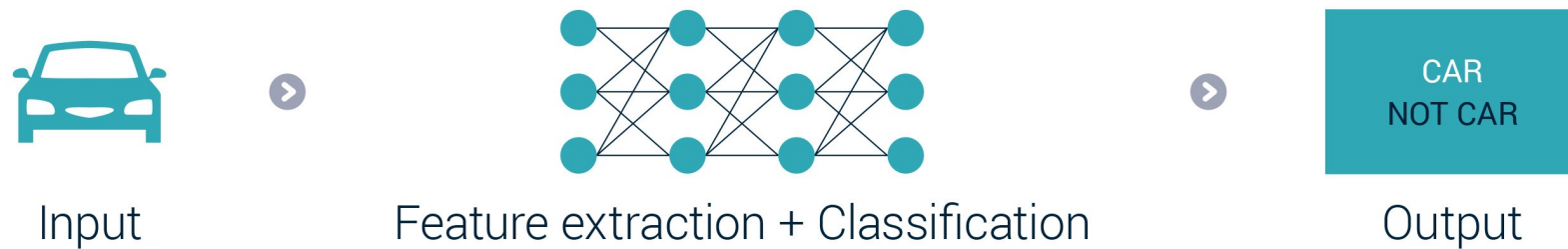


Machine learning tasks for graph data

Machine Learning

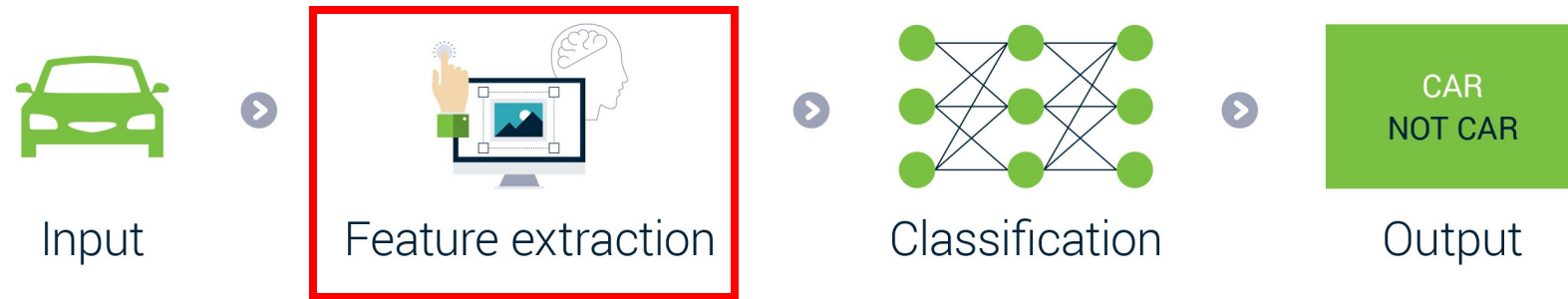


Deep Learning

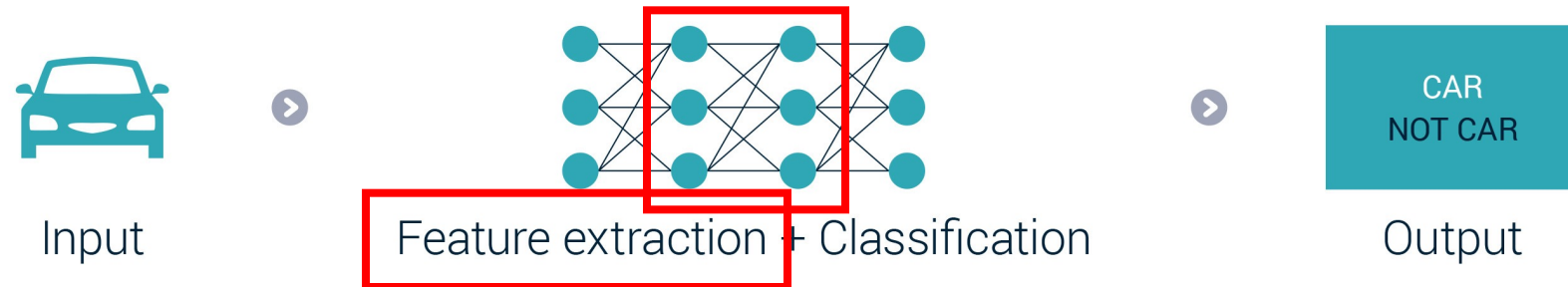


Machine learning tasks for graph data

Machine Learning



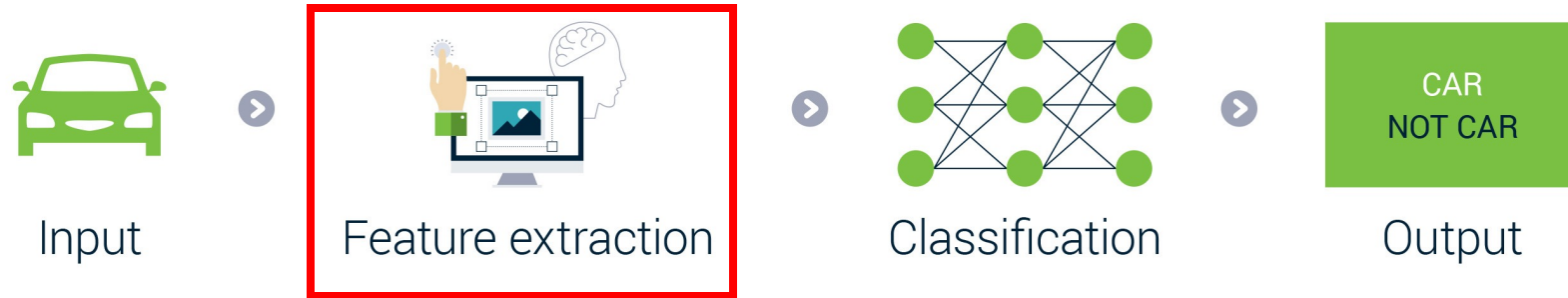
Deep Learning



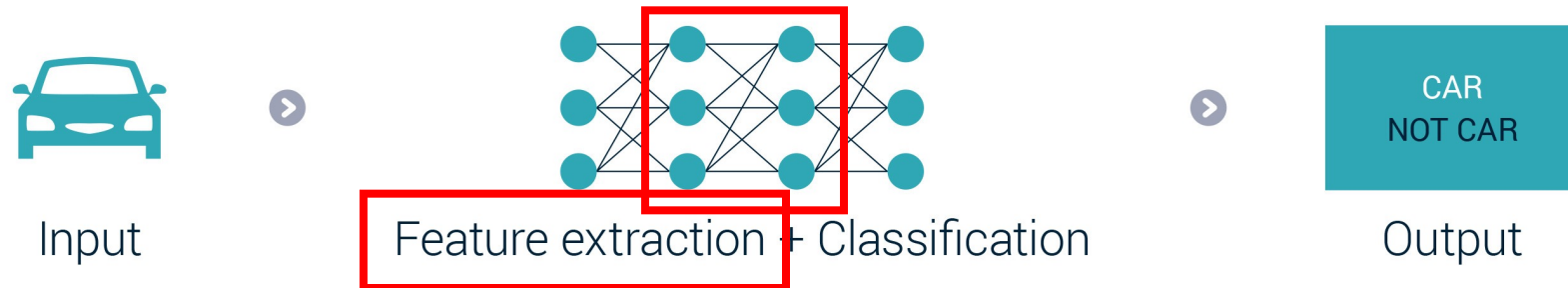
Machine learning tasks for graph data

Machine Learning

Consider correlations



Deep Learning

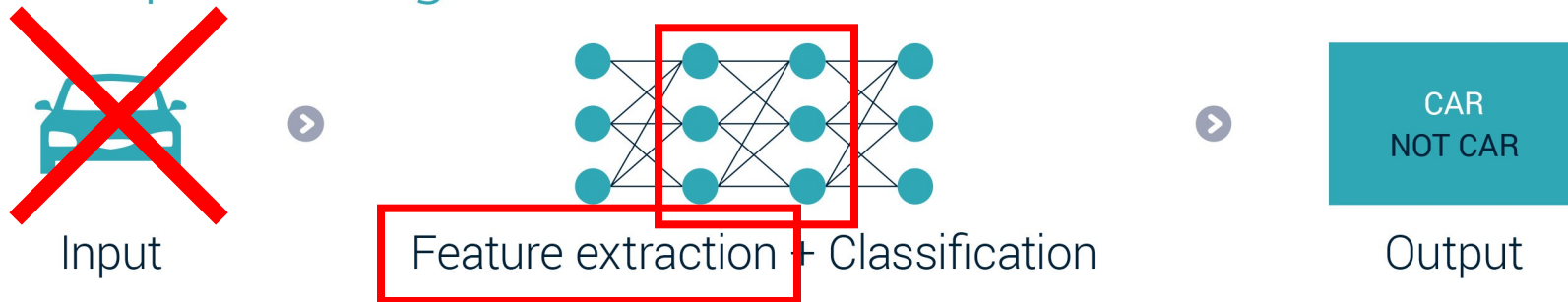


Machine learning tasks for graph data

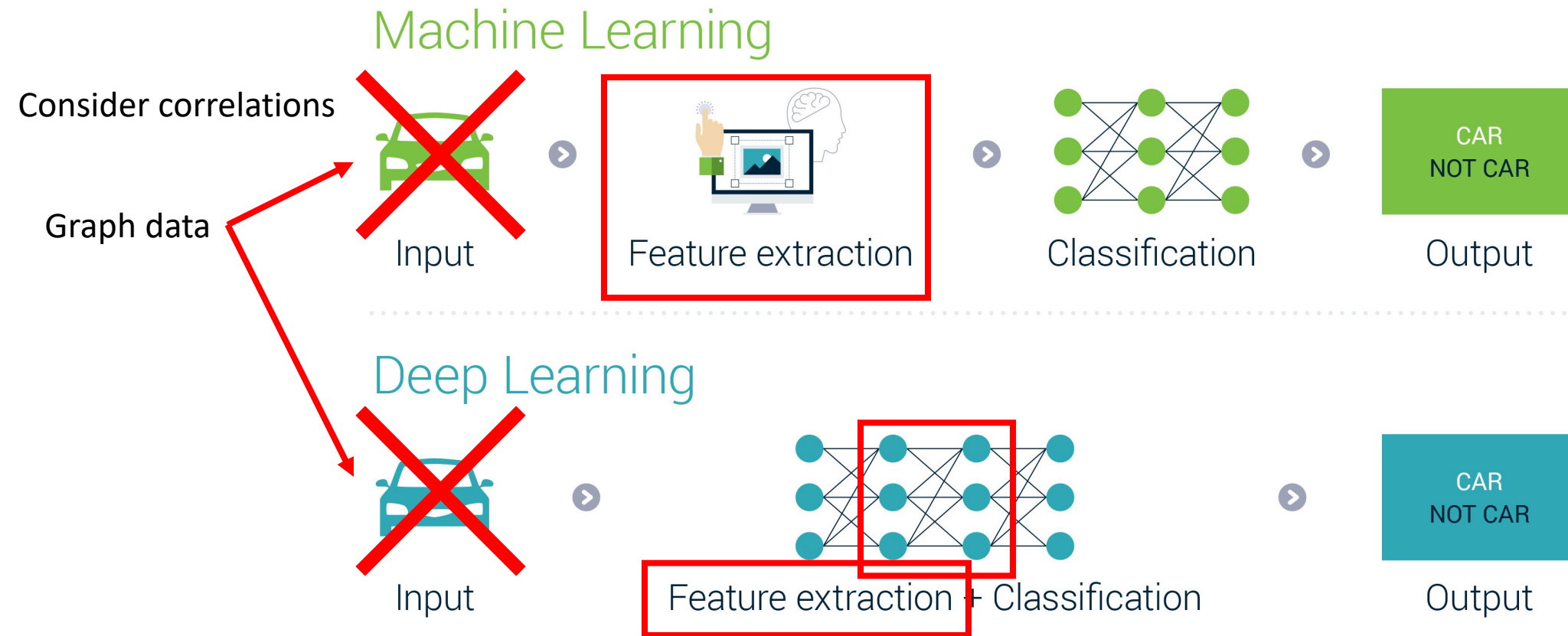
Machine Learning



Deep Learning



Machine learning tasks for graph data



Machine learning tasks for graph data

