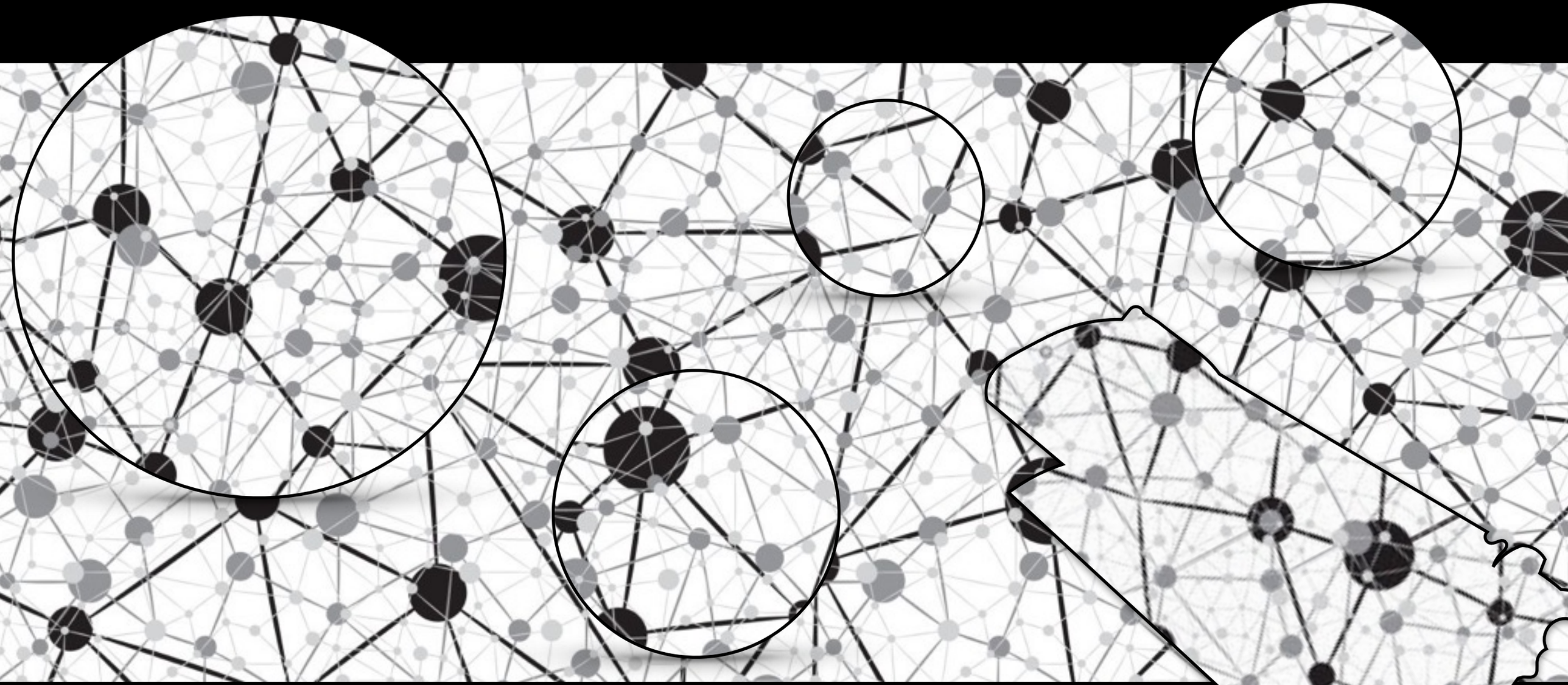
# Finding Patterns in Planets



## Using neural networks to explore the Kepler catalogue

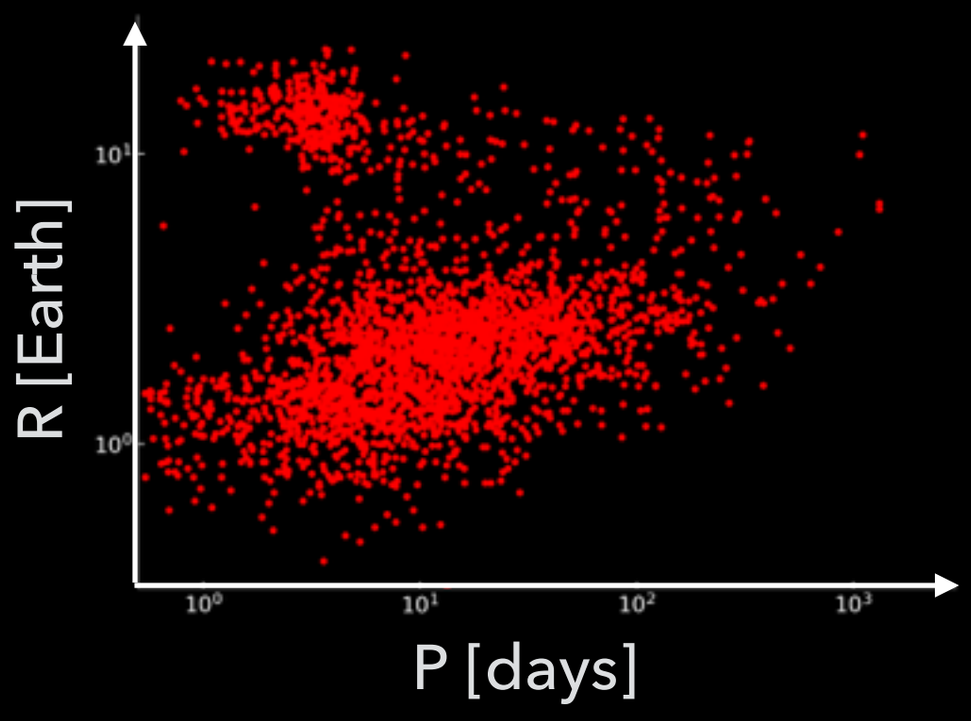
# Collaborators

Nicholas Guttenberg

ARAYA

Matthieu Laneuville

# Human brain challenges



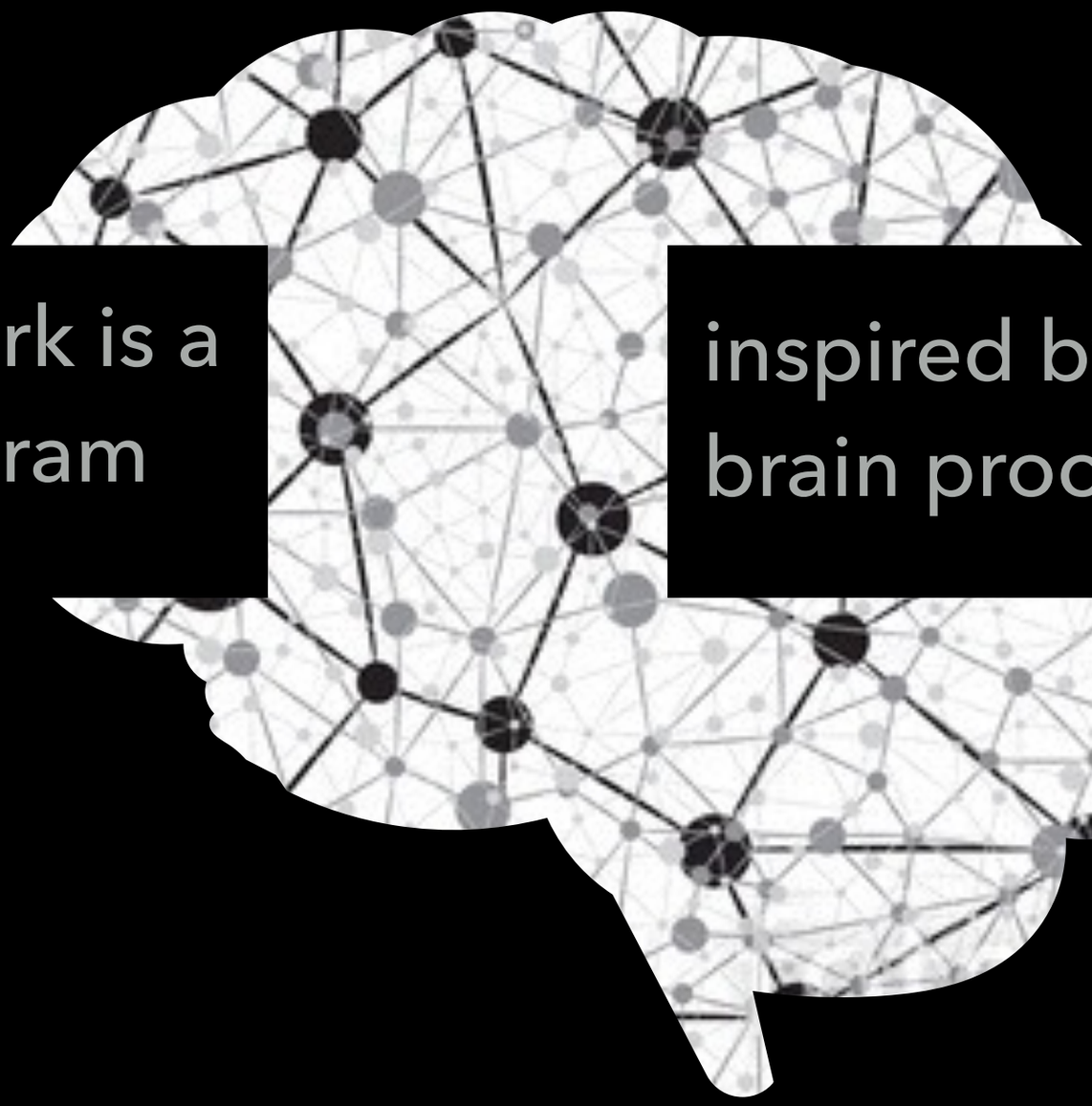

Easiest to explore trends between only 2 - 3 parameters.

Can miss higher dimensional connections.

Trends may also be  missed if they aren't expected...

... and nothing about planet formation has been expected.

# Neural Networks



A neural network is a computer program

inspired by the way the brain processes information.

Given a large collection of examples, a NN will identify patterns.

# Concept

# Concept

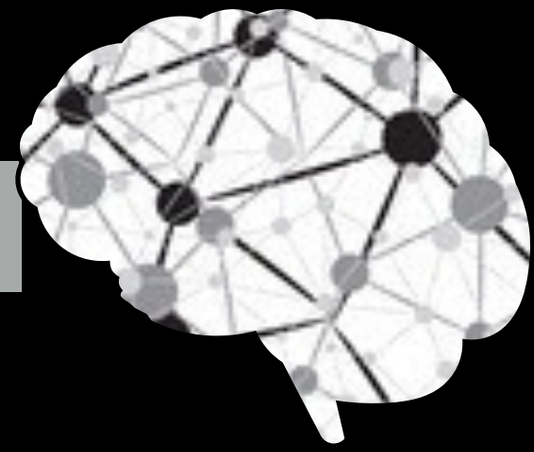

Red

Four wheels

Two floors

London

Carry people

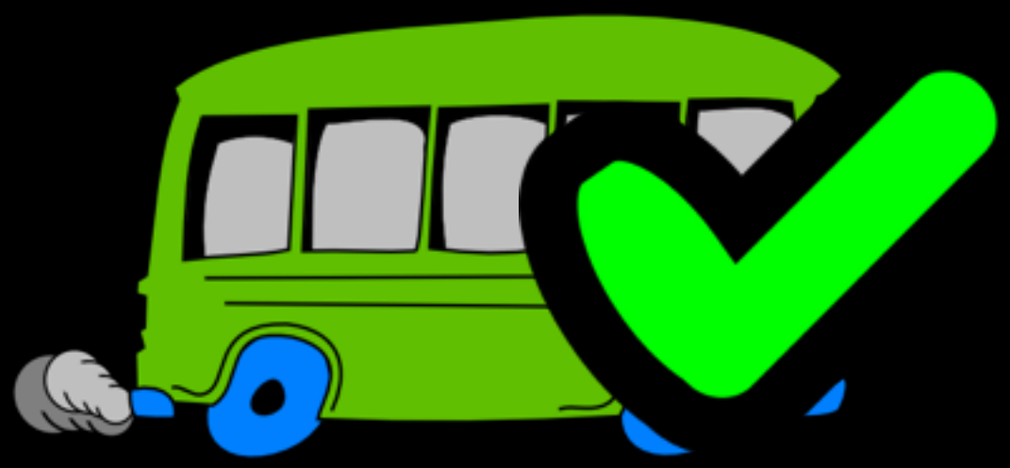


# Concept


Carry many people

Fixed route

Involves a fee



# NN structure

Red

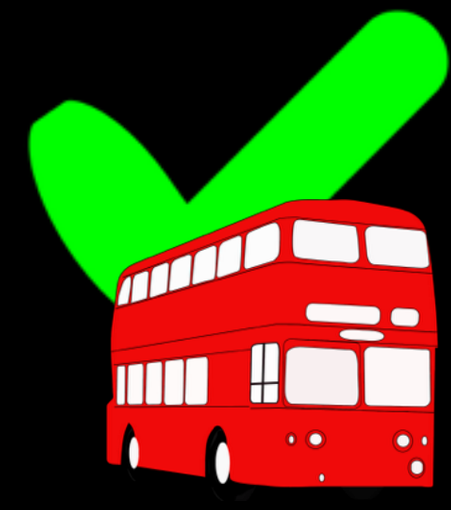
W1

Fixed route

W2

W3

Carry people



INPUT FEATURES WEIGHTS ACTIVATION RESULT

W1 = W2 = W3

# NN structure

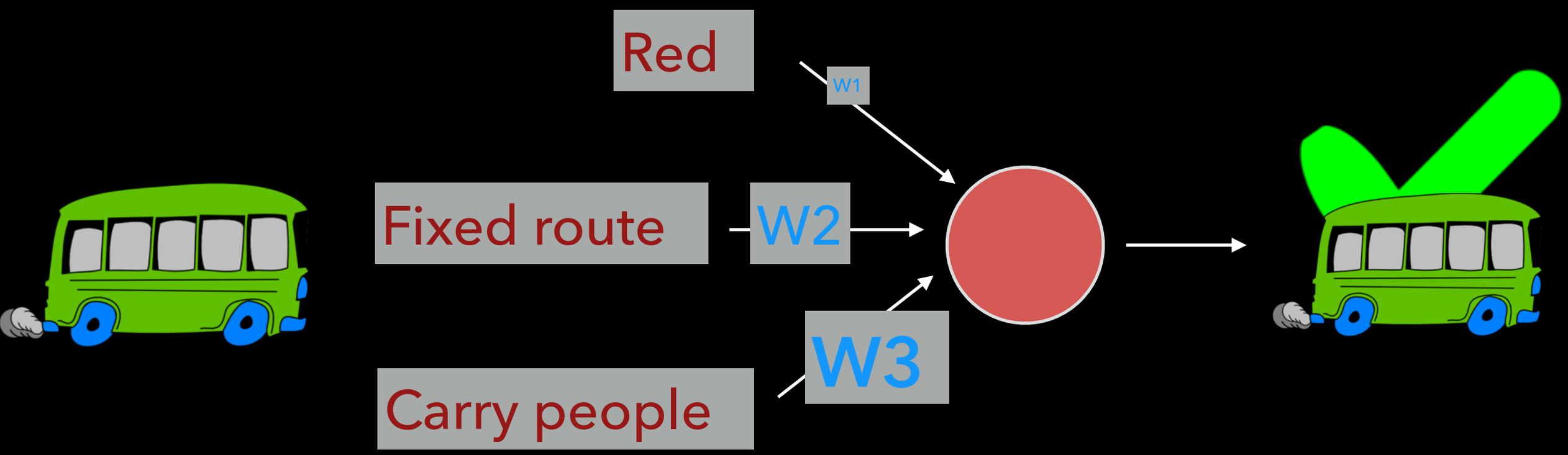



INPUT FEATURES WEIGHTS ACTIVATION RESULT

W1 = W2 = W3

OPTIMISER

# NN structure

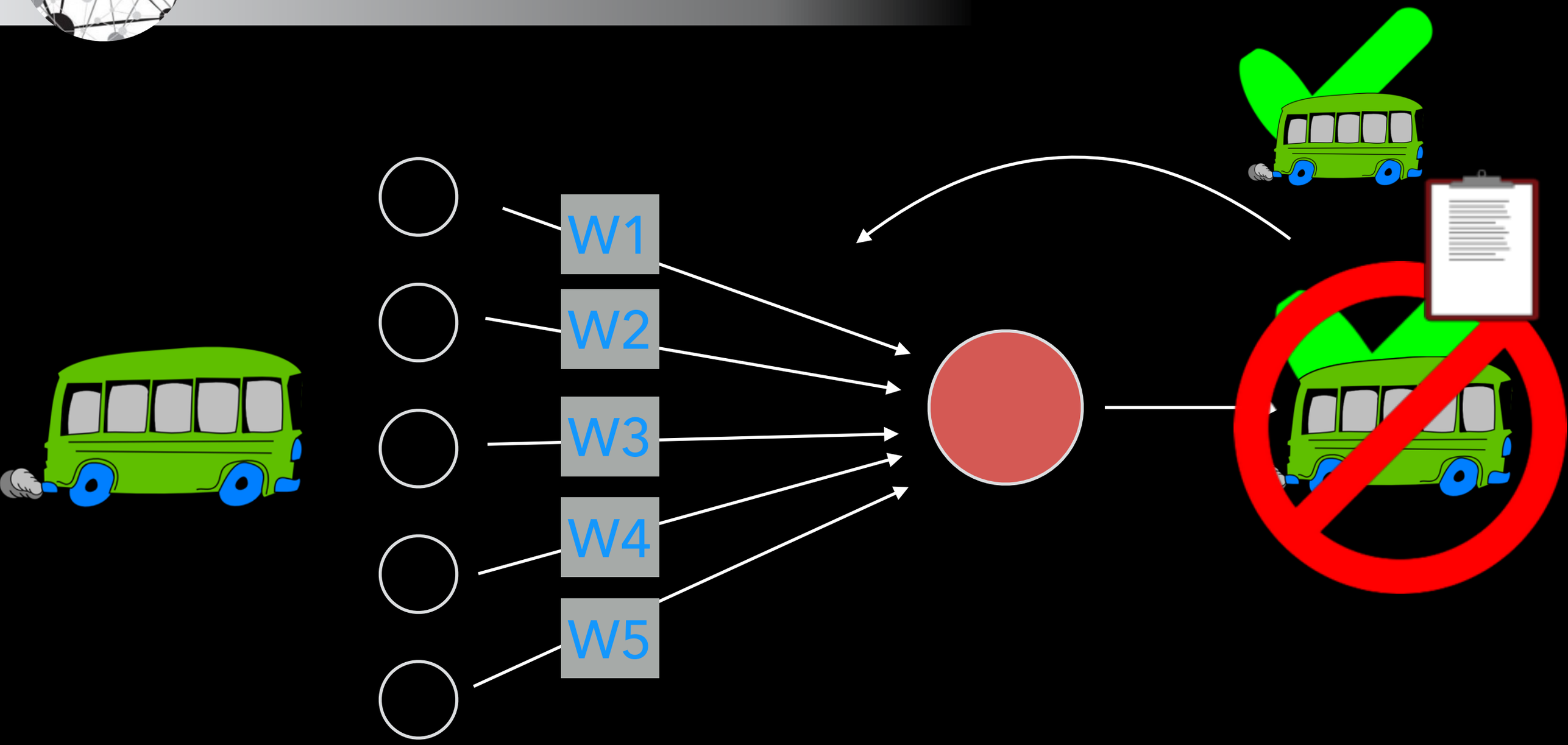



INPUT FEATURES WEIGHTS ACTIVATION RESULT

W1 < W2 < W3

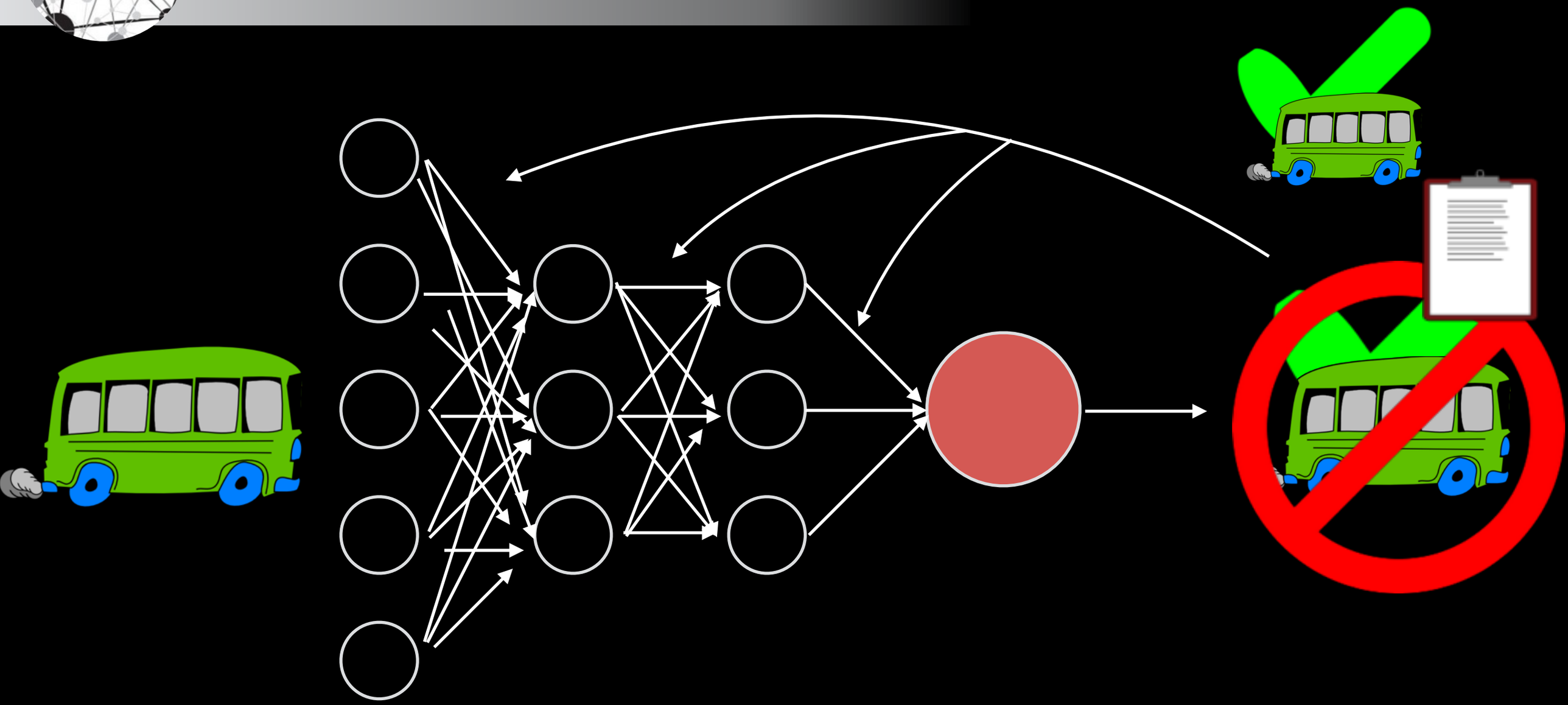
OPTIMISER

# NN structure




Can choose feature or ‘node’ number …

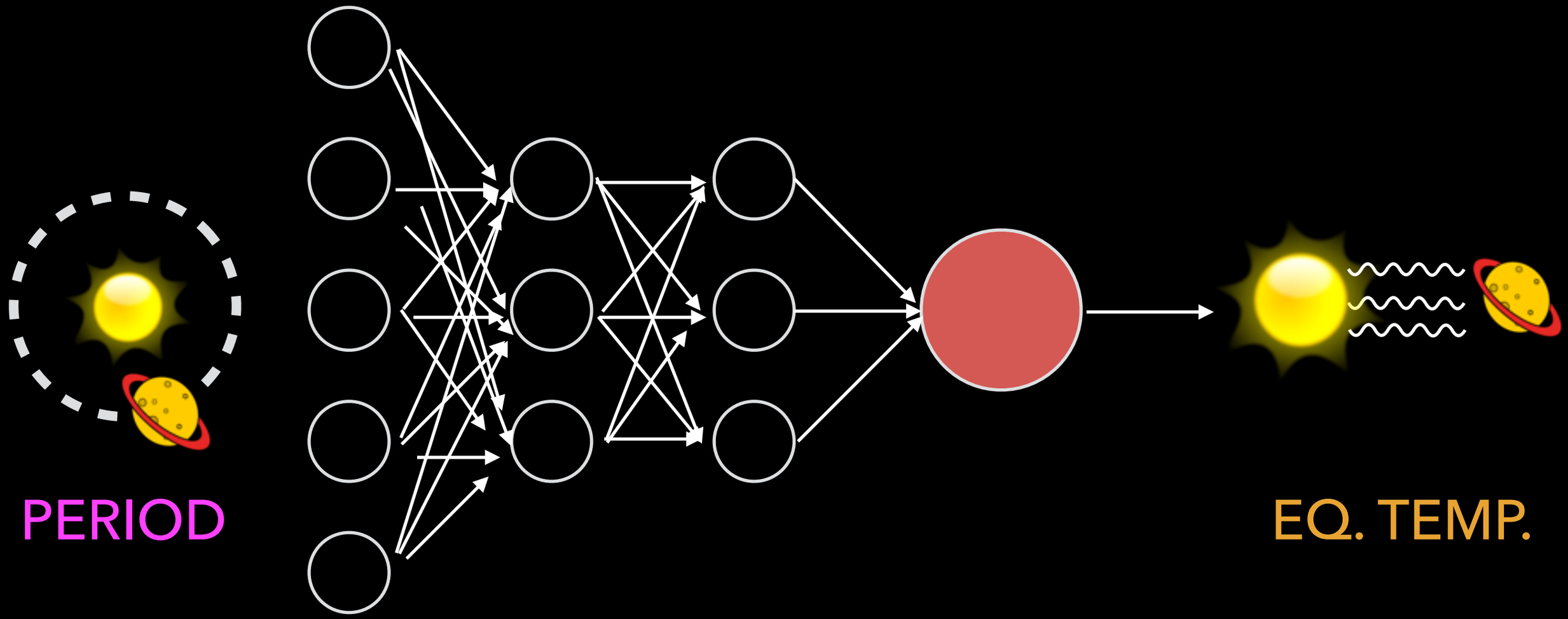
# NN structure



Can choose feature or ‘node’ number …  and number of layers

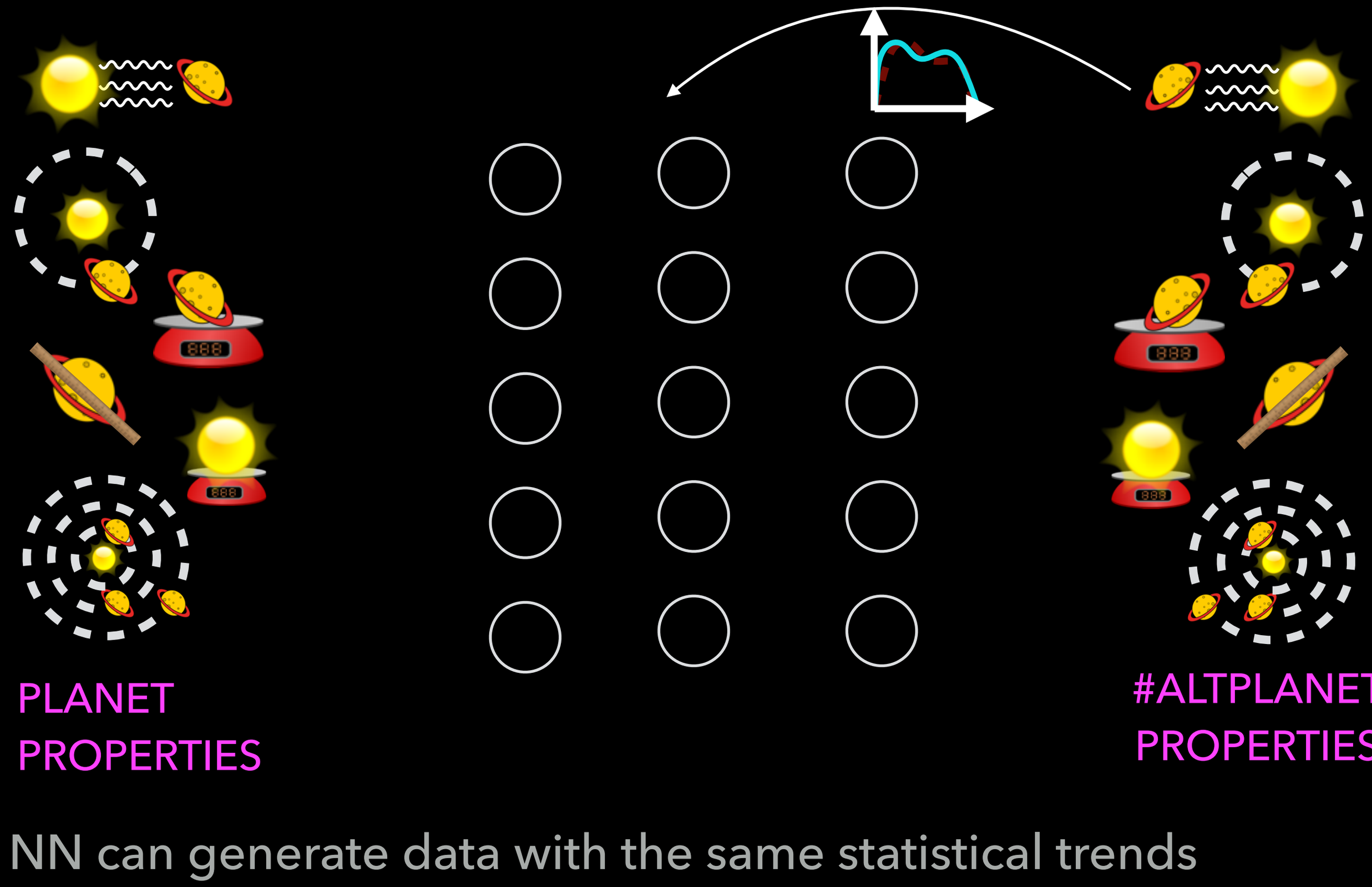
But network finds what each node represents by itself.

# Trend Finder



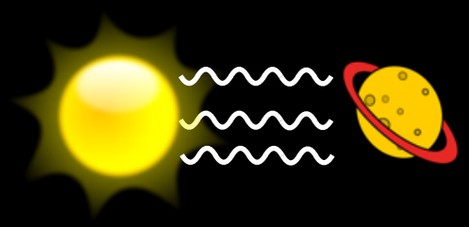

NN can easily find relations.

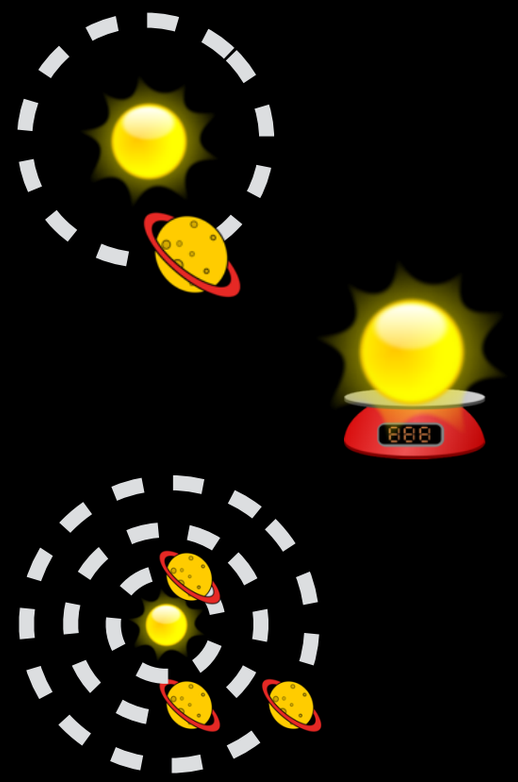
# Trend Finder

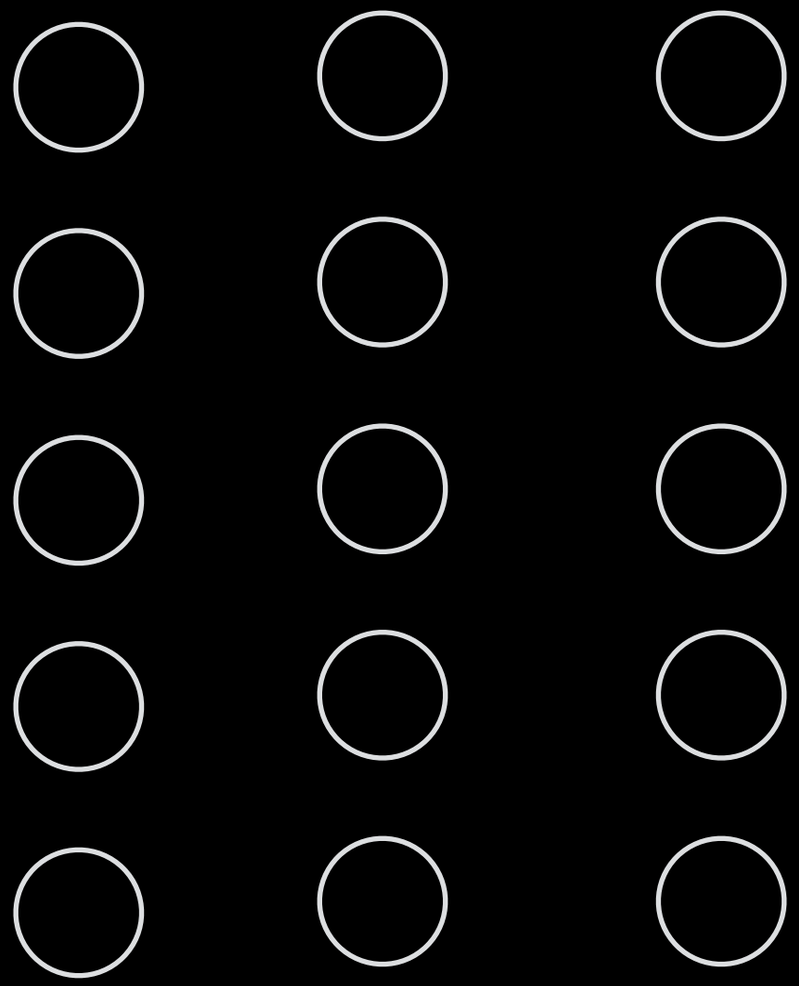



NN can generate data with the same statistical trends

# Trend Finder



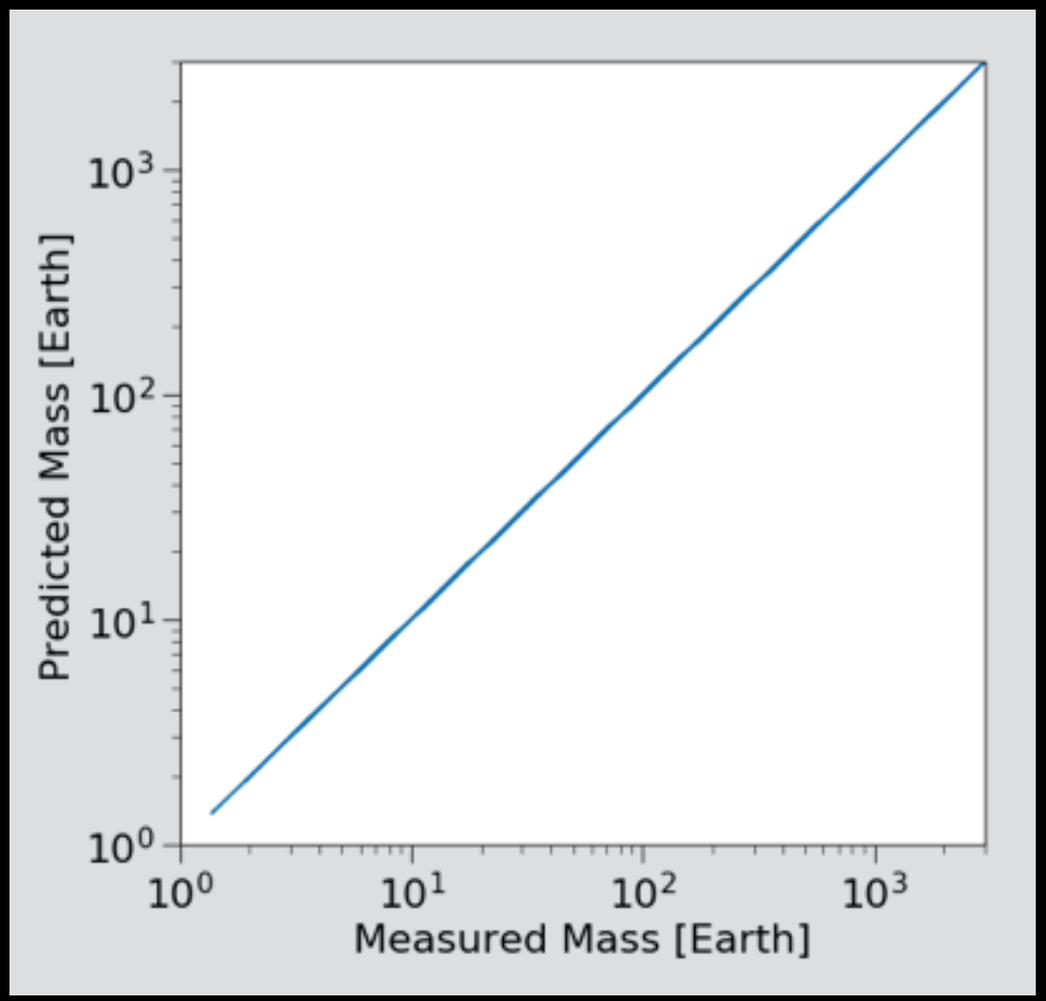




p(M)

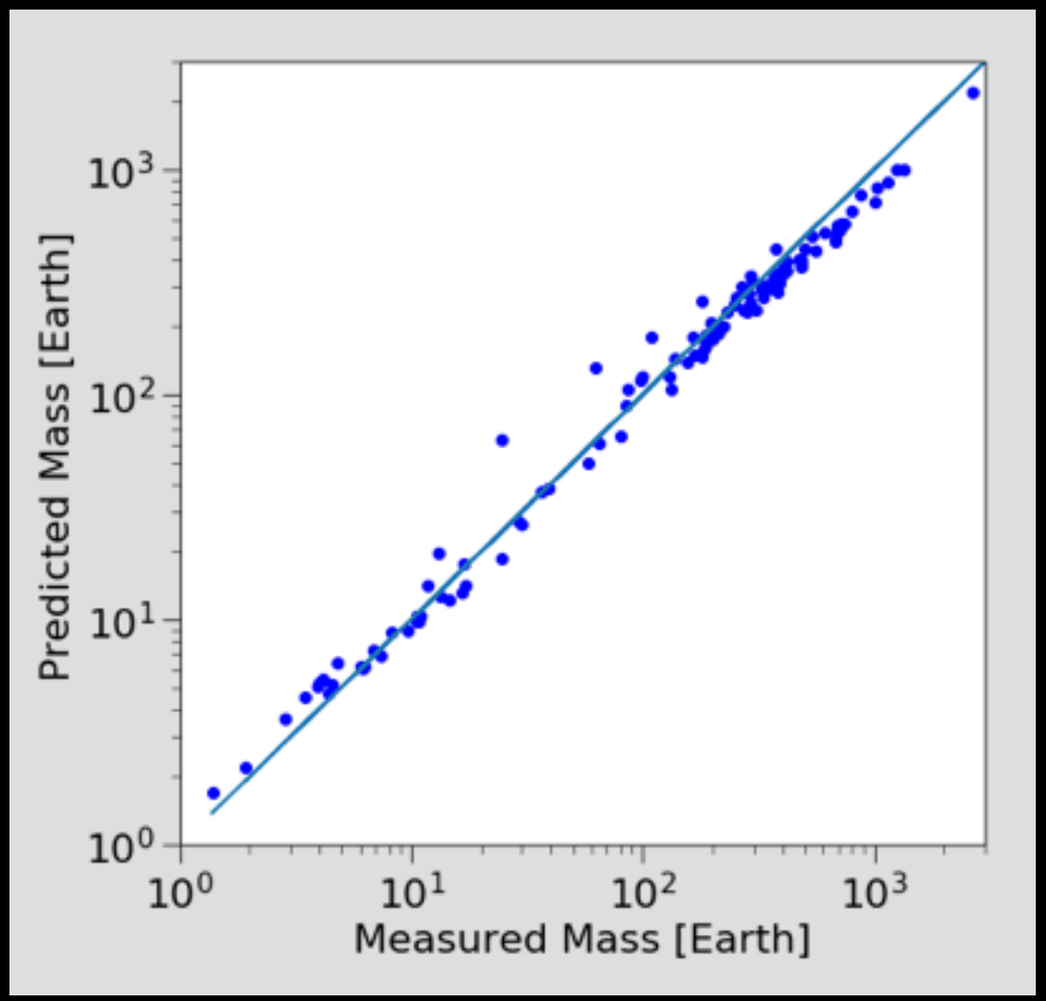
... and then generate missing fields.

# Trend Finder




Let's try it on planets with a measured mass...

# Trend Finder

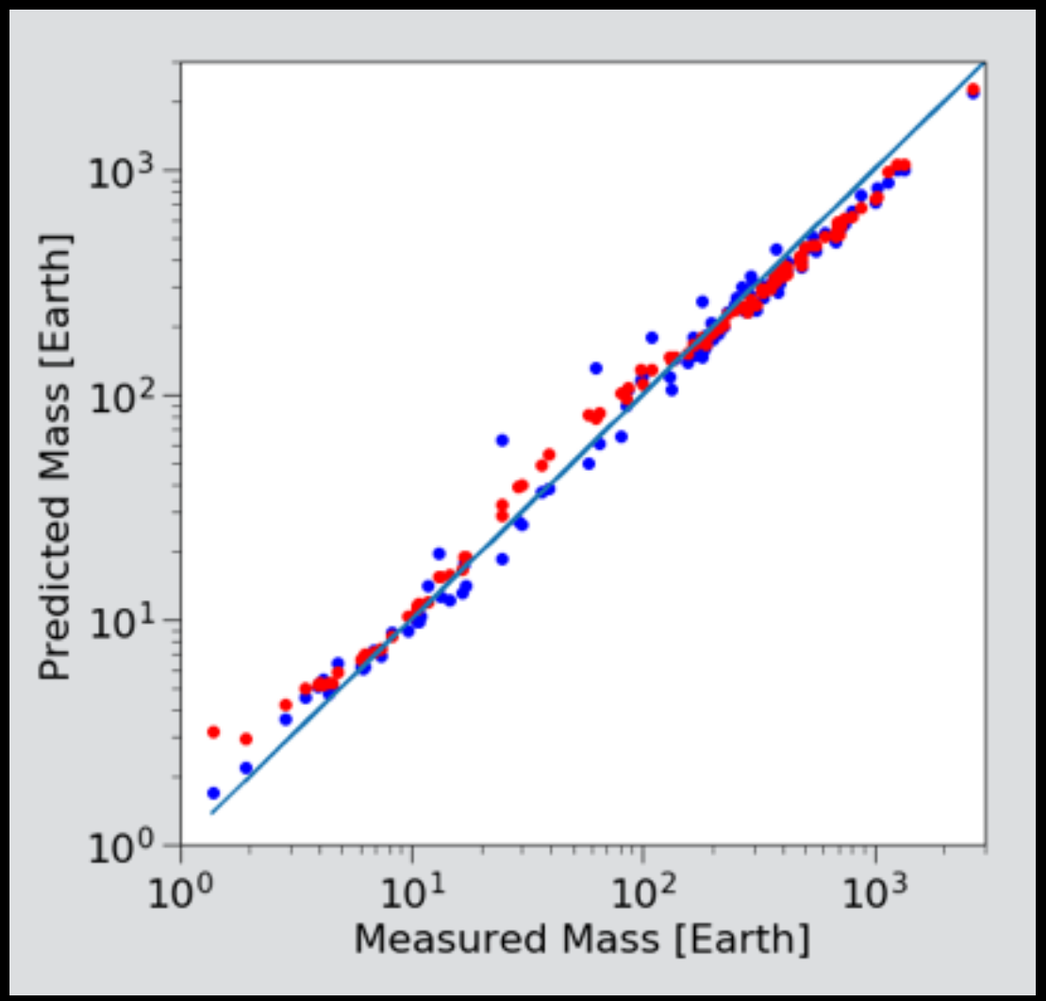



Let's try it on planets with a measured mass…

Looks good but …. !

Compare with combining with distribution of known planets

# Trend Finder




Let's try it on planets with a measured mass…

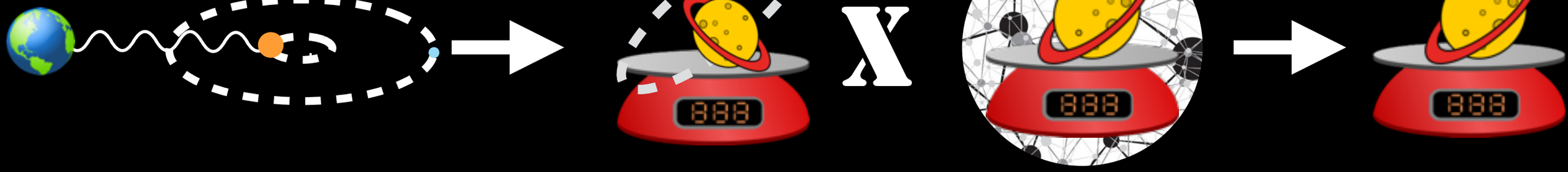
Looks good but …. !

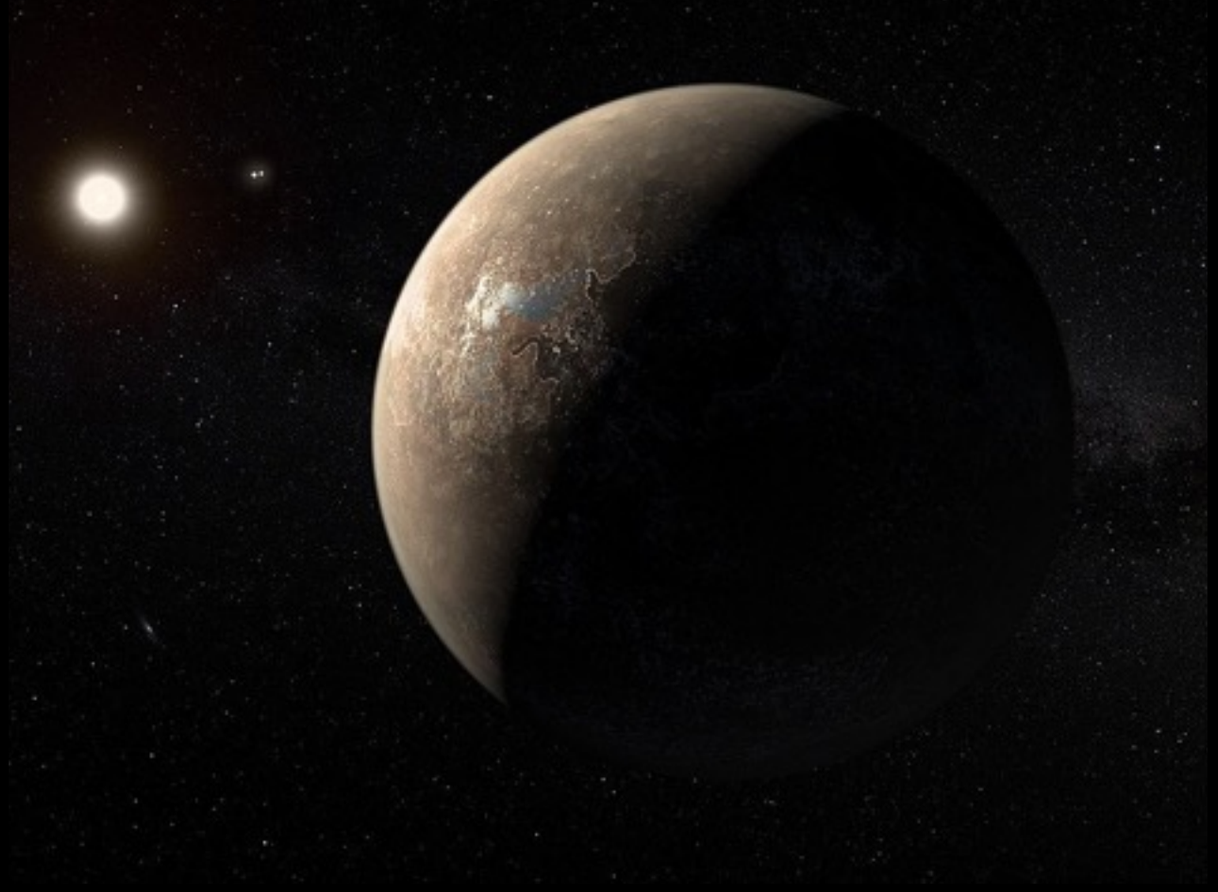
Compare with combining with distribution of known planets

Very slightly better…

MSE 0.5 → 0.46

# Trend Finder





Proxima Centauri-b

~ 1.3

~ 1.8

# Trend Finder

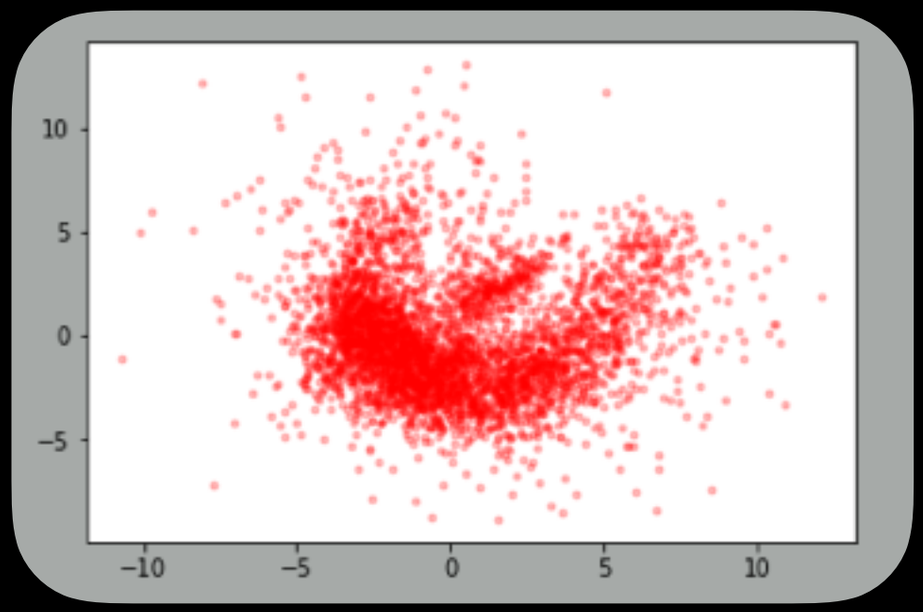
Bottleneck:

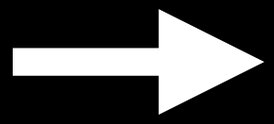
PLANET
PROPERTIES

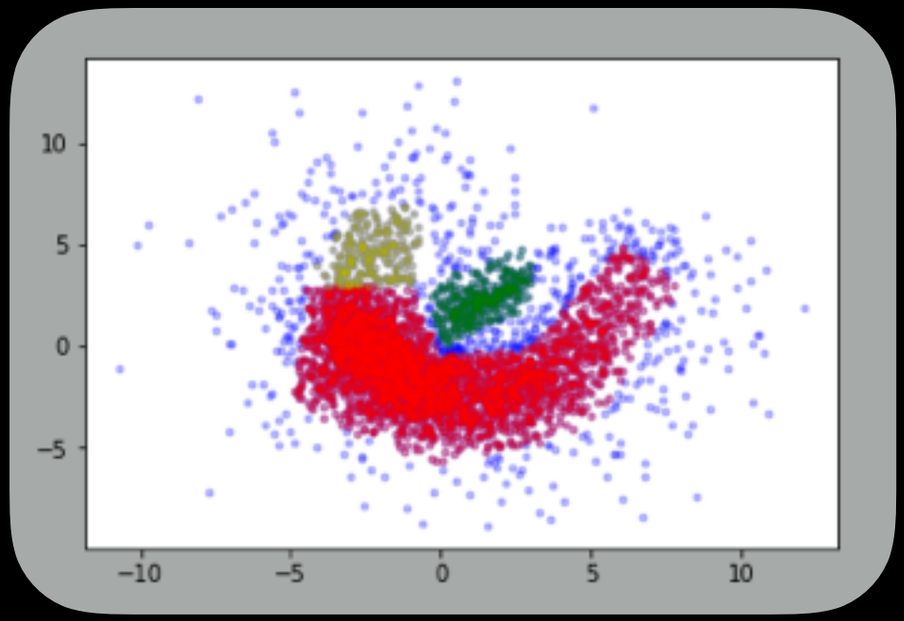
#ALTPLANET
PROPERTIES

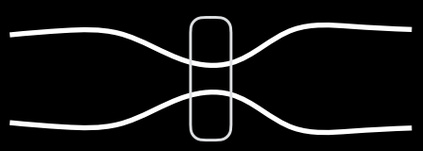
All information encoded in a small number of nodes

# Trend Finder



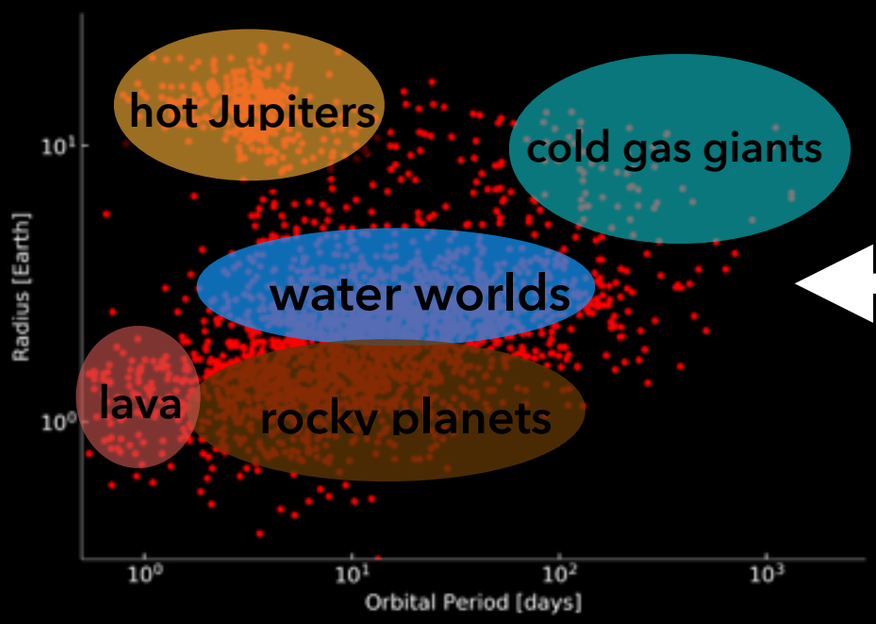



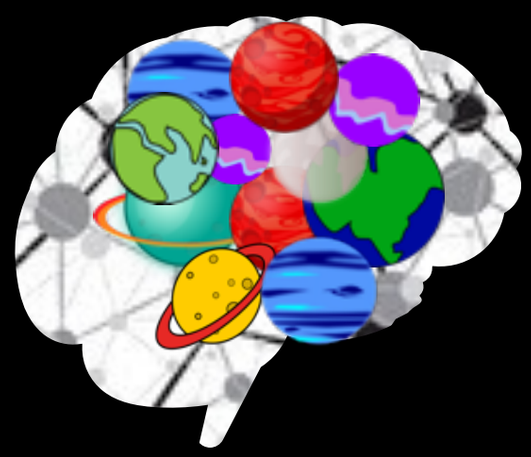


Embedded space at the bottleneck

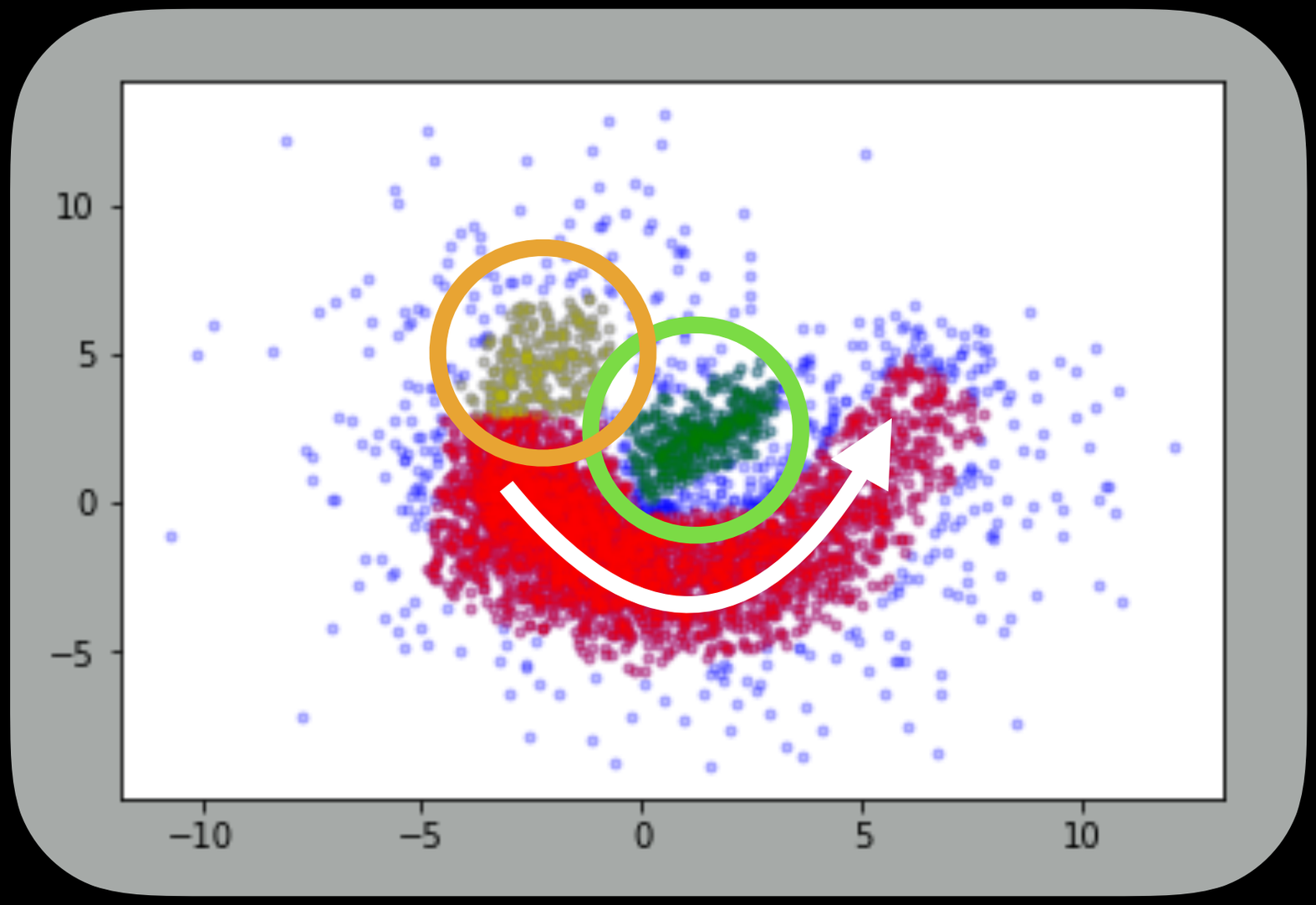
Identify planet groups



Reveals trends the NN thinks dominate

# Trend Finder




Increase in period

M-dwarfs

Ultra-short period

# Neural Networks

Advantages

- Independent search for correlations in planet properties
  (Compared to other techniques)

- Trends involving a large number of parameters possible

- No compensation for observational bias (!)
  (Reflects the raw data: sanity check)