

# Artificial Intelligence CONFERENCE

PUT AI TO WORK  
SEPT 17-18: TRAINING  
SEPT 18-20: TUTORIALS & CONFERENCE  
SAN FRANCISCO, CA

13:30 - 14:30

## BUILDING BRAINS - PARALLELISATION STRATEGIES OF LARGE-SCALE DEEP LEARNING NEURAL NETWORKS ON PARALLEL SCALE OUT ARCHITECTURES LIKE APACHESPARK USING GPUS

ROMEO KIENZLER , IBM WATSON IOT , CHIEF DATA SCIENTIST

New deep learning frameworks are being developed on a monthly basis. For most of them, the inventors ... [Read more](#)

Location: Room 14b



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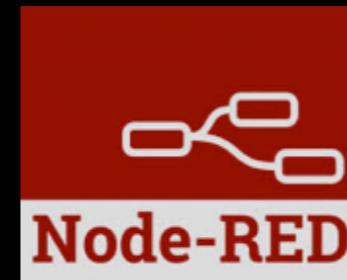
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- \$3B investment
- Partners including
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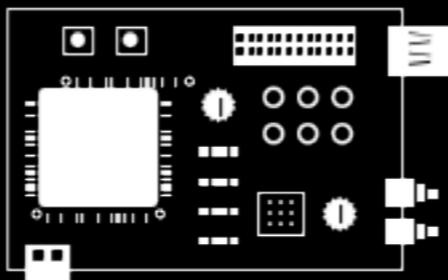


# Why IoT (now) ?

- 15 Billion connected devices in 2015
- 40 Billion connected devices in 2020
- World population 7.4 Billion in 2016

Now you can believe the hype

# OASIS makes MQTT gold standard for Internet of Things



## Your device or gateway

We start with your device, be it a sensor, a gateway or something else. To find out how to get it connected, search our recipes.



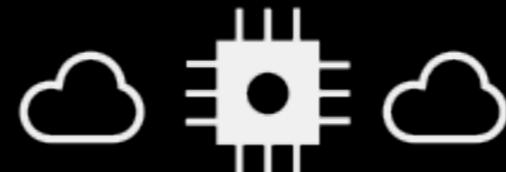
## MQTT & HTTP

Your device data is sent securely up to the cloud using the open, lightweight MQTT messaging protocol or HTTP.



## REST & Real-time APIs

Use our secure APIs to connect your apps with the data coming from your devices.



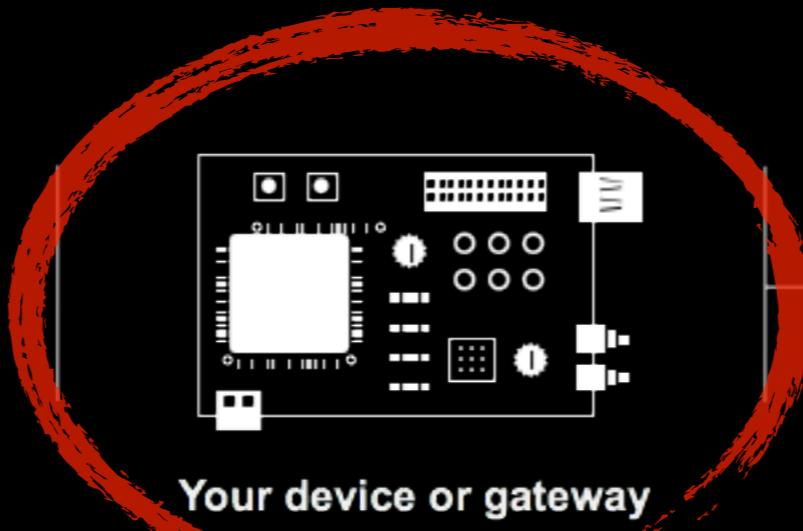
## IBM Watson IoT Platform

This is the hub of all things IBM IoT. This is where you can setup and manage your connected devices so that your apps can access their live and historical data.



## Your application and analytics

Create applications within IBM Bluemix, another cloud, or your own servers to interpret the data you now have access to!



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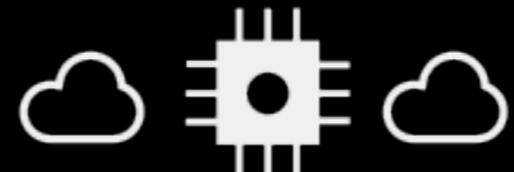
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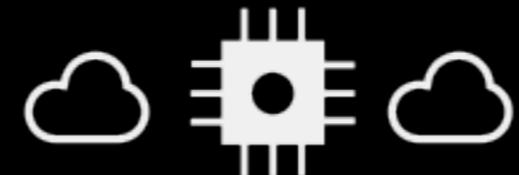
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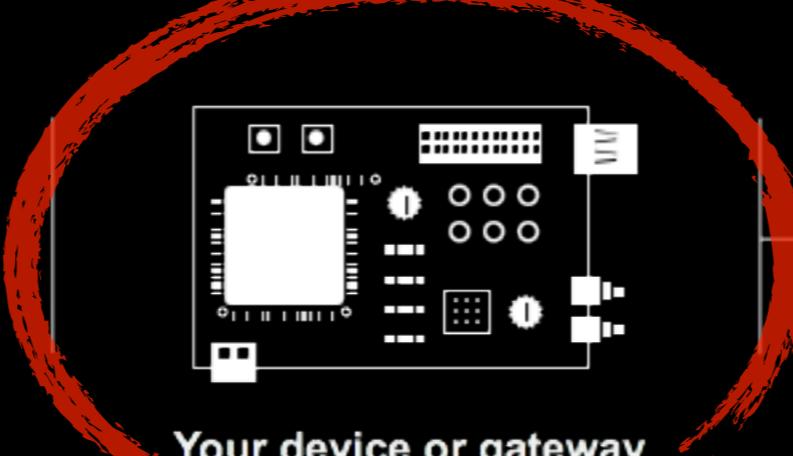
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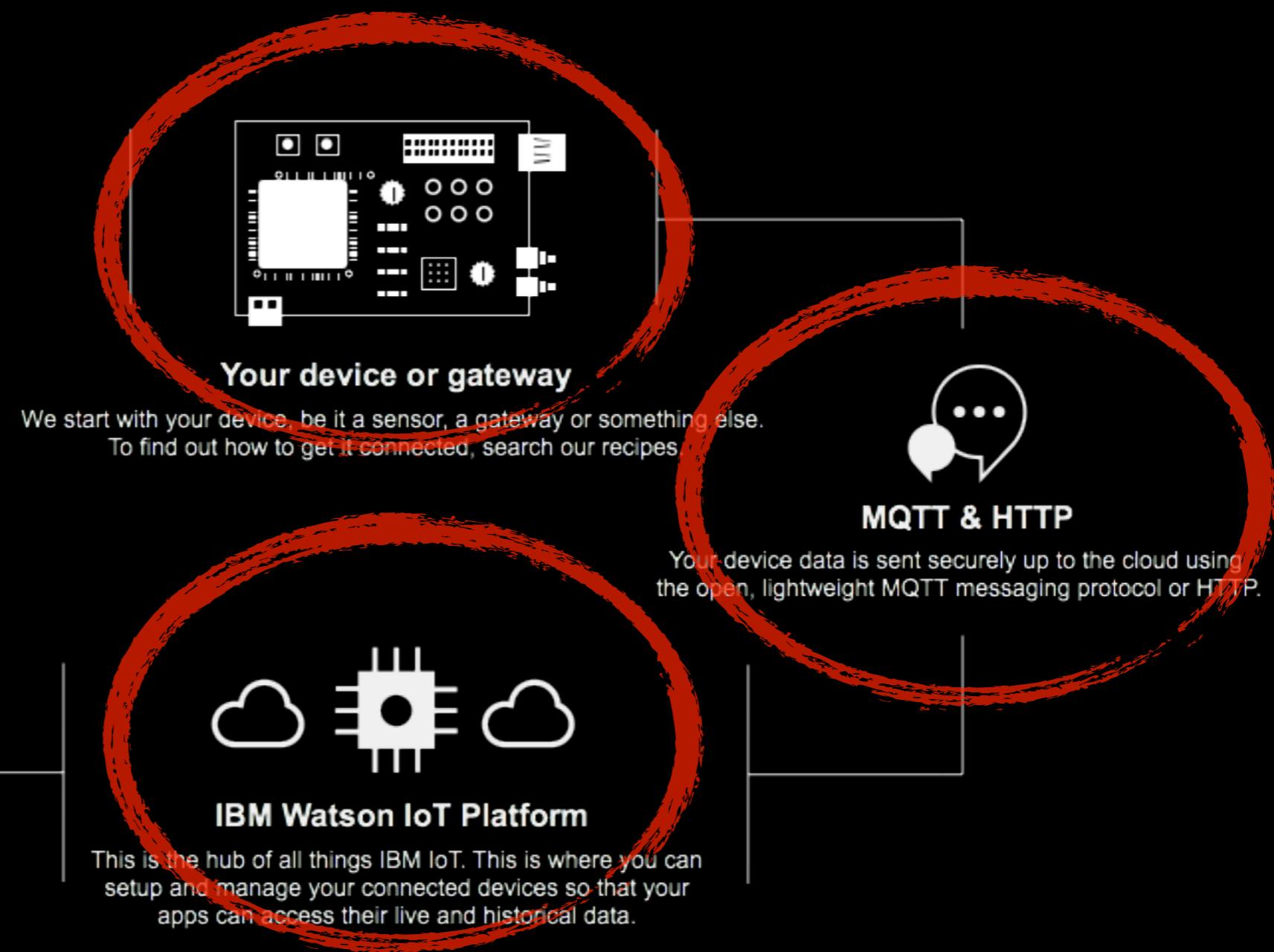
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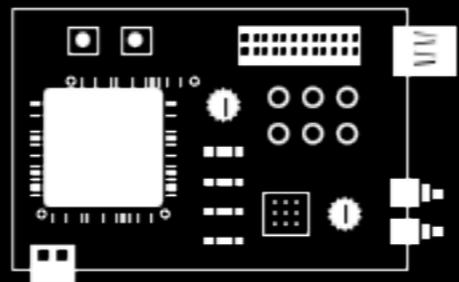
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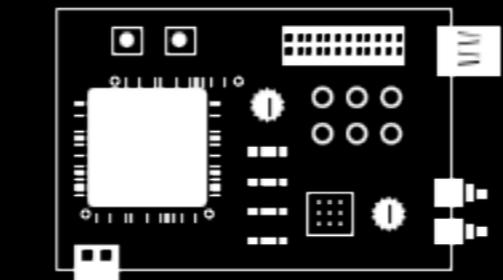
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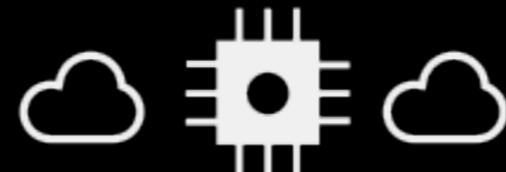
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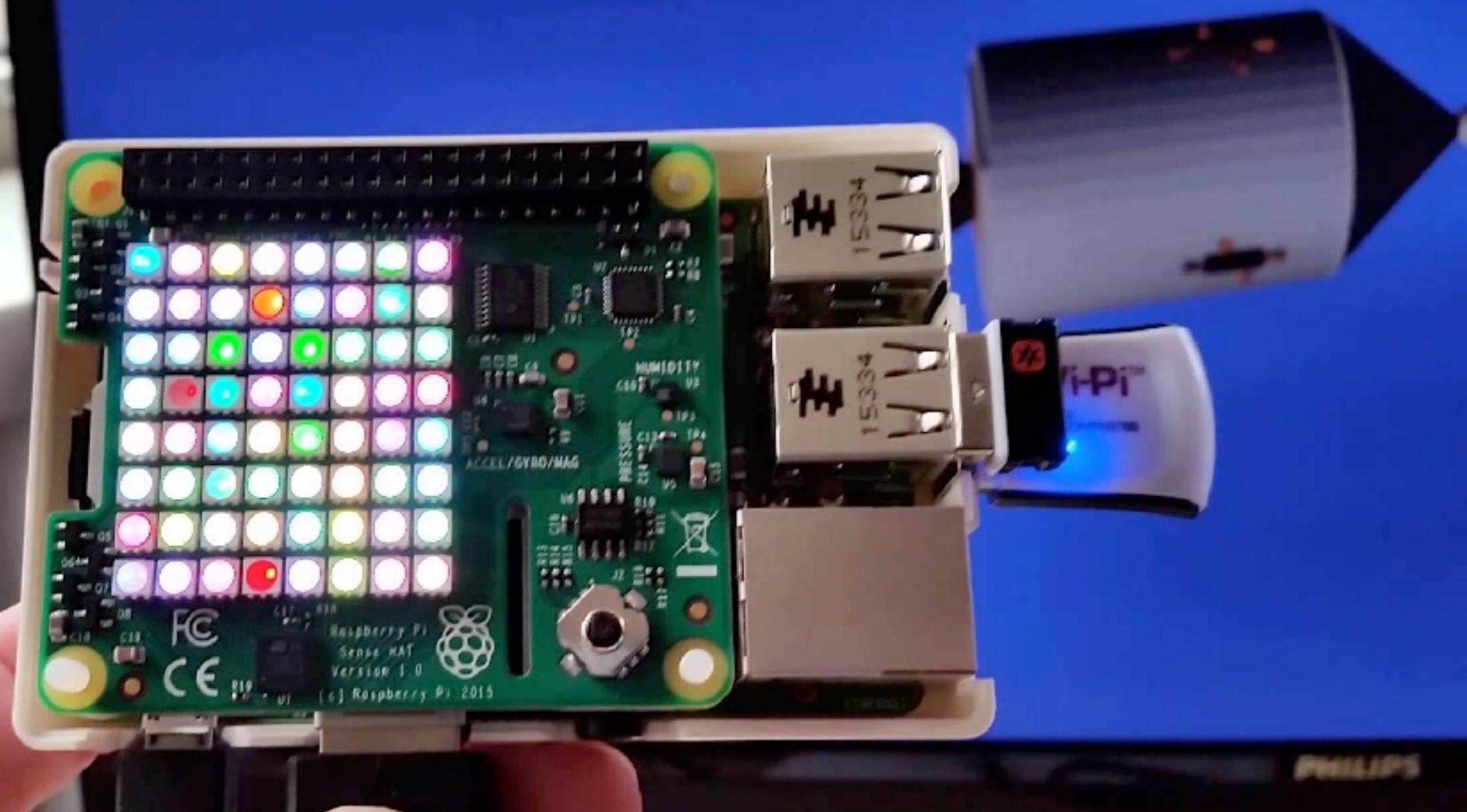
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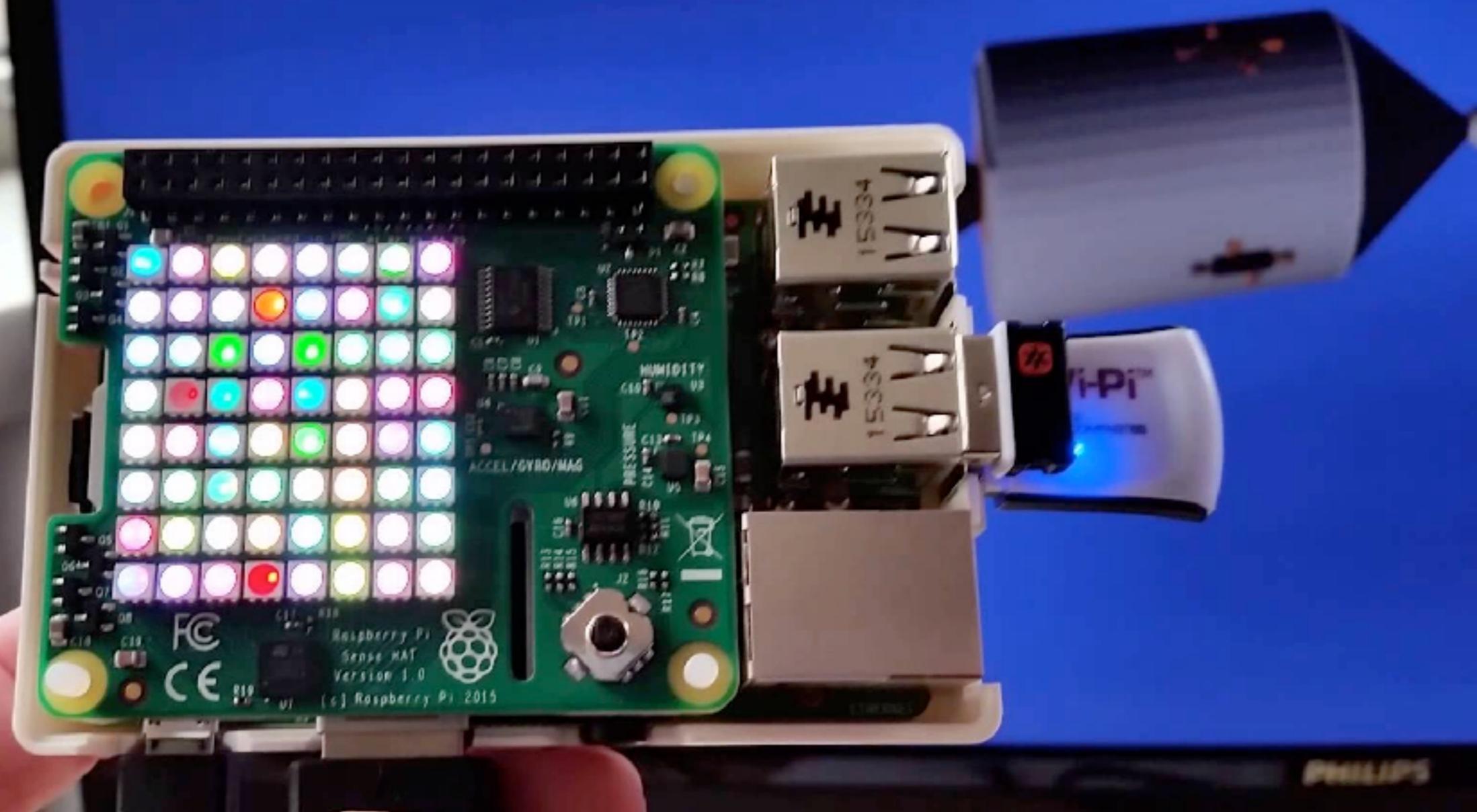
## Your application and analytics

Create applications within IBM Bluemix, another cloud, or your own servers to interpret the data you now have access to!



```
import ibmiotf.gateway
from sense_hat import SenseHat
gatewayOptions = {"auth-method": "token", "auth-token": "s*)3uX"}
gatewayCli = ibmiotf.gateway.Client(gatewayOptions)
gatewayCli.connect()
sense = SenseHat()

temp = sense.get_temperature()
myData = { 'temp' : temp}
gatewayCli.publishDeviceEvent(myData, qos=2)
```



```
import ibmiotf.gateway
from sense_hat import SenseHat
gatewayOptions = {"auth-method": "token", "auth-token": "s*)3uX"}
gatewayCli = ibmiotf.gateway.Client(gatewayOptions)
gatewayCli.connect()
sense = SenseHat()
```

```
at Run$MyEventCallback$2$.processEvent(Run.scala:43)
at com.ibm.iotf.client.app.ApplicationClient.messageArrived(ApplicationClient.java:973)
at org.eclipse.paho.client.mqttv3.internal.CommsCallback.deliverMessage(CommsCallback.java:477)
```



# A developer's guide to the Internet of Things (IoT)

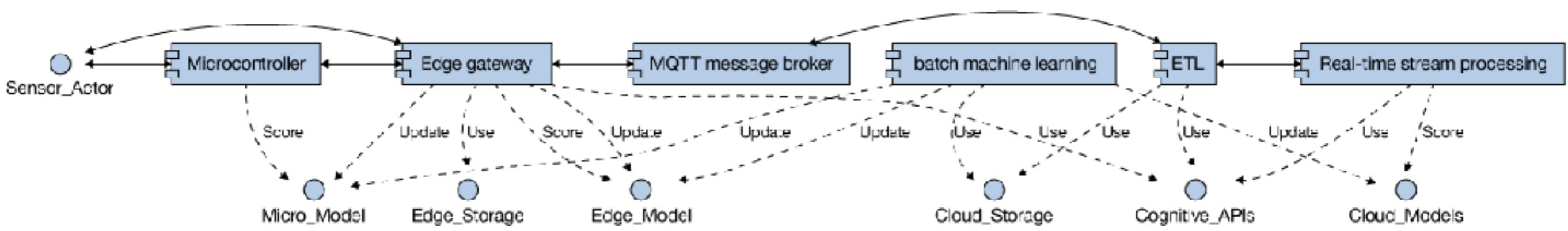
IBM

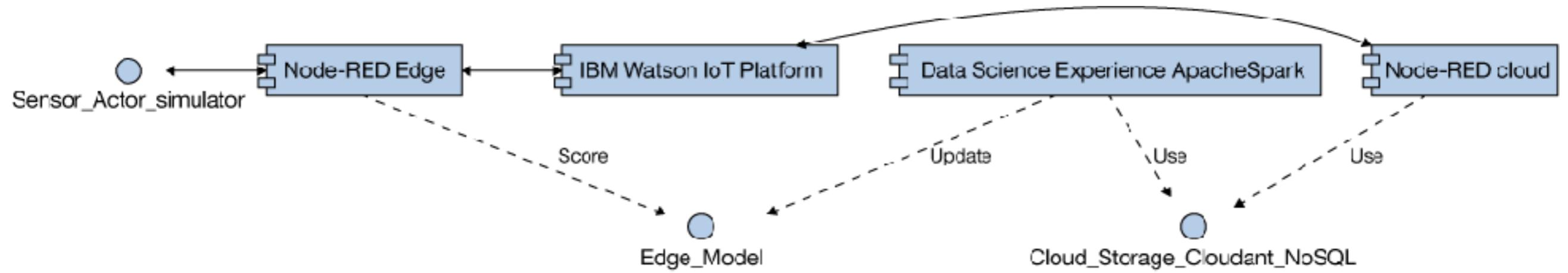
coursera

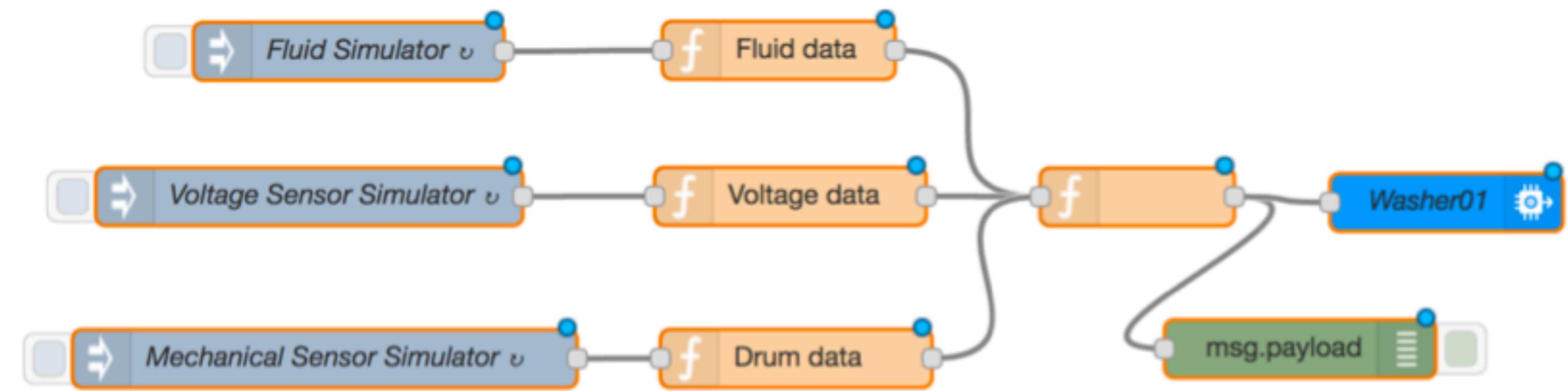
A developer's guide  
to the Internet of  
Things (IoT)

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Starting May 2016

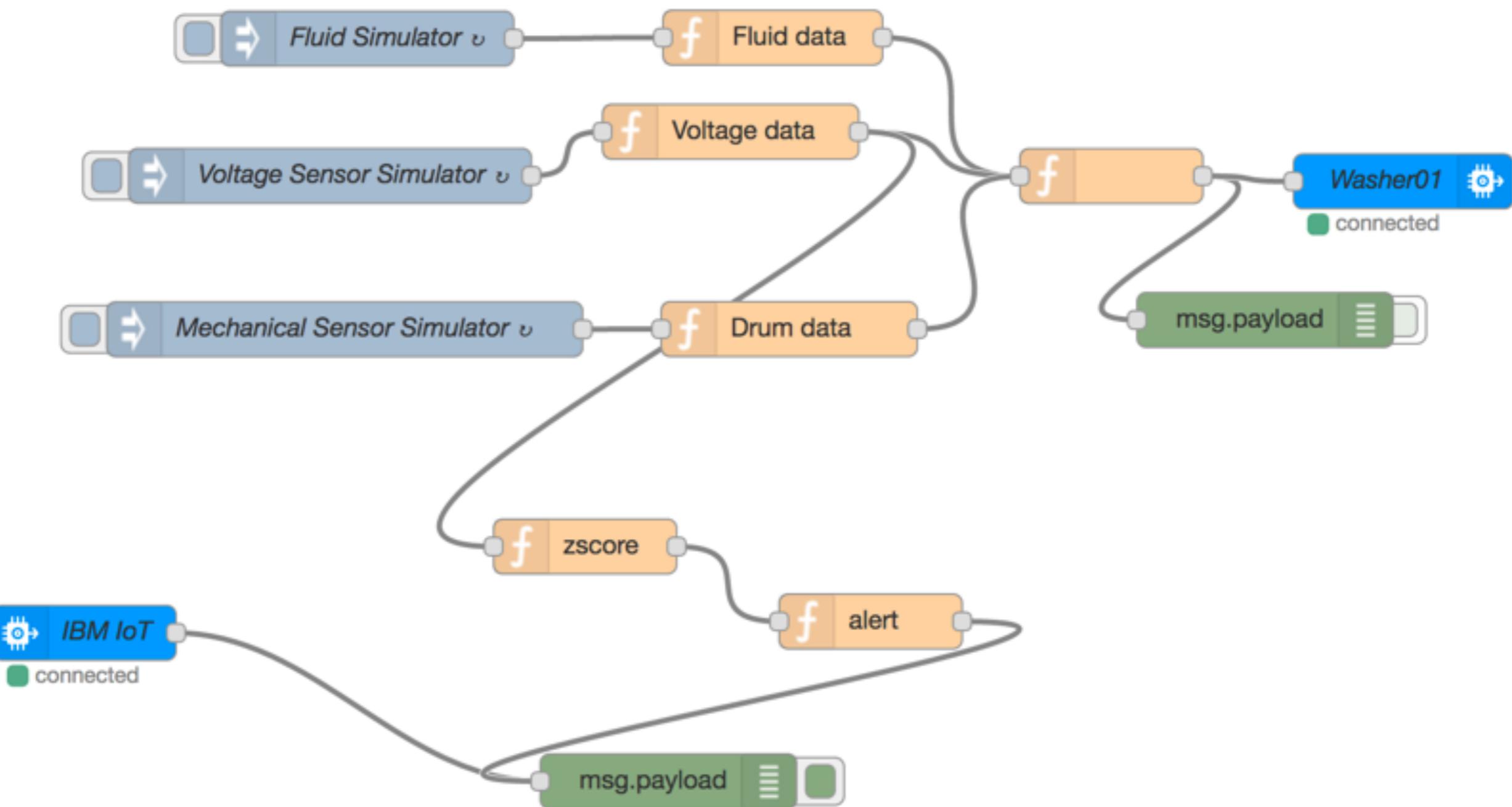






Flow 1

Flow 2



# A developer's guide to Exploring and Visualizing IoT Data



**Created by:** IBM



A developer's guide  
to Exploring and  
Visualizing IoT Data

**Enroll Now**

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2017



**Taught by:** Romeo Kienzler, Chief Data Scientist  
IBM Watson IoT

# A developer's guide to Exploring and Visualizing IoT Data



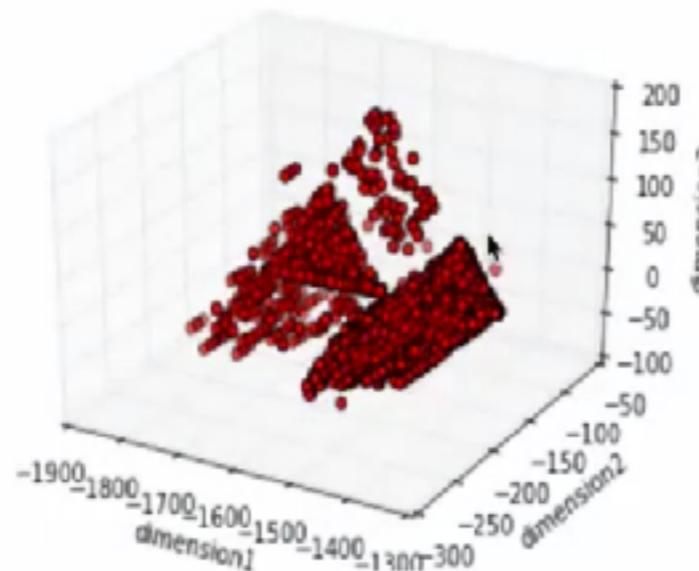
File Edit View Insert Cell Kernel Help

CellToolbar

```
ax.scatter(x,y,z, c='r', marker='o')

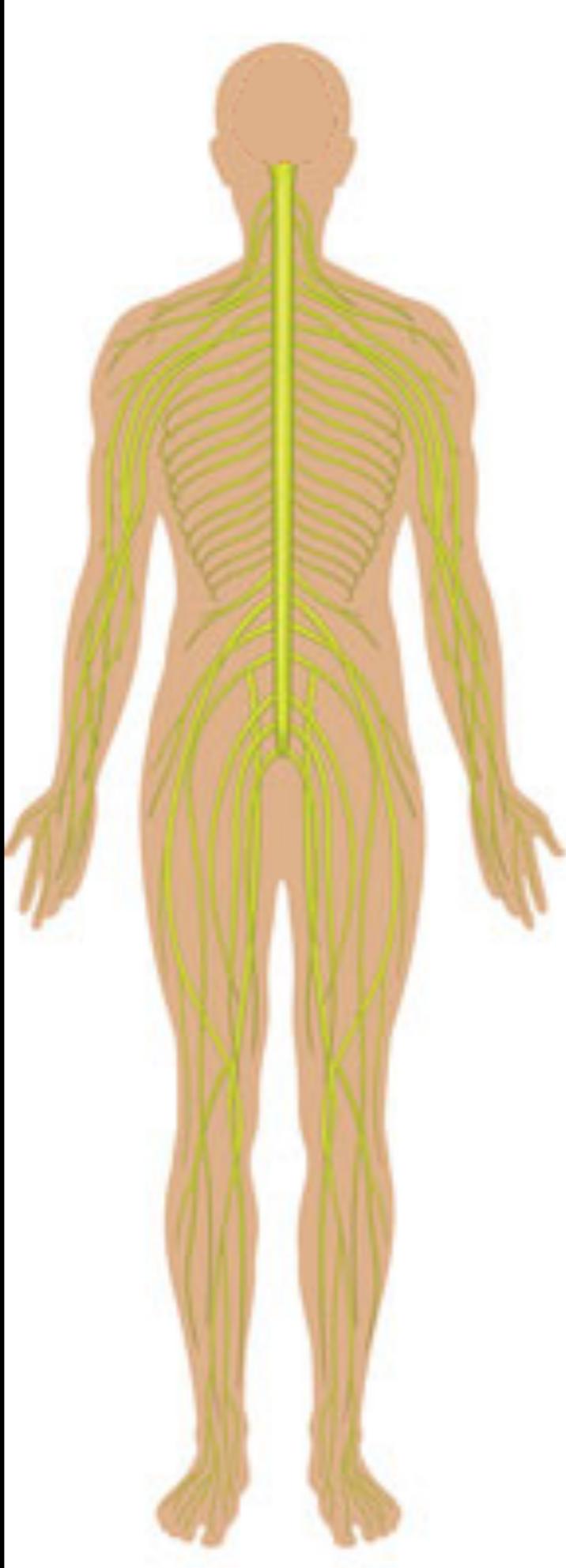
ax.set_xlabel('dimension1')
ax.set_ylabel('dimension2')
ax.set_zlabel('dimension3')

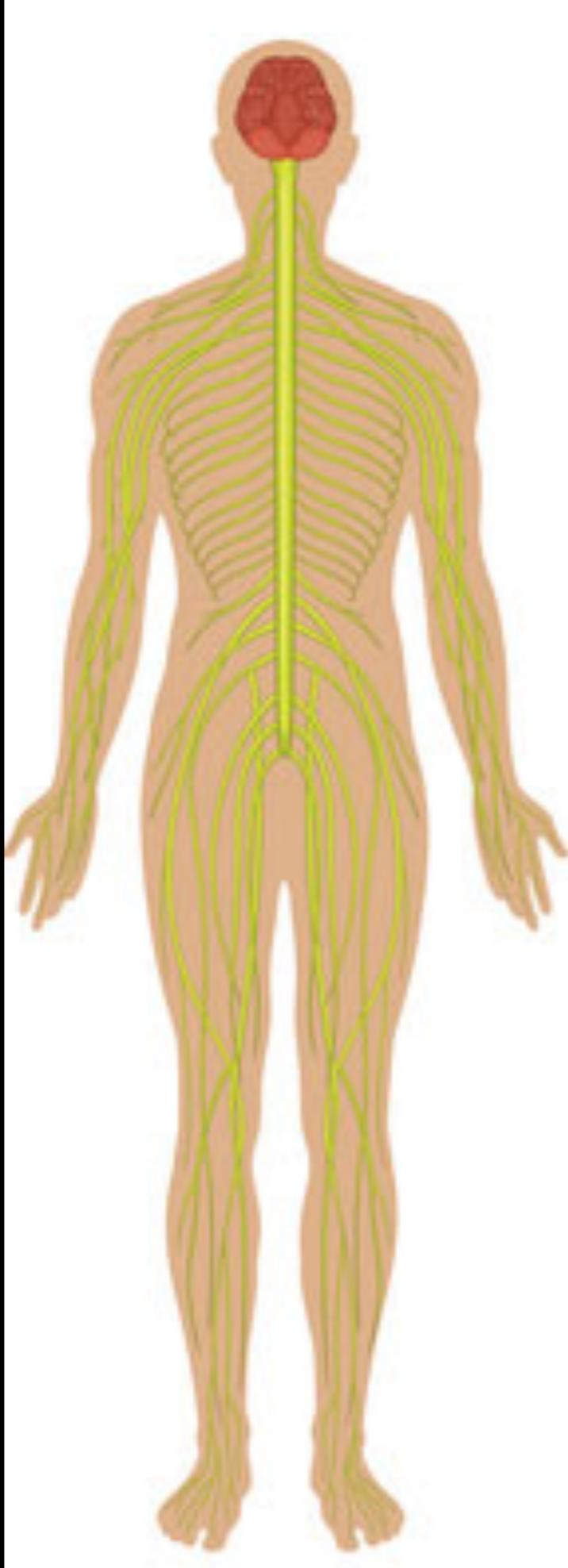
plt.show()
```



A developer's guide  
to Exploring and  
Visualizing IoT Data

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 PDF  MP3  Appstores  Bilder  Multi URL

## **Webseite (URL)**

<http://ibm.biz/boomboomshakeshake>

- Statisch
- Dynamisch ( Was bedeutet Dynamisch? )

#### QR Code erstellen

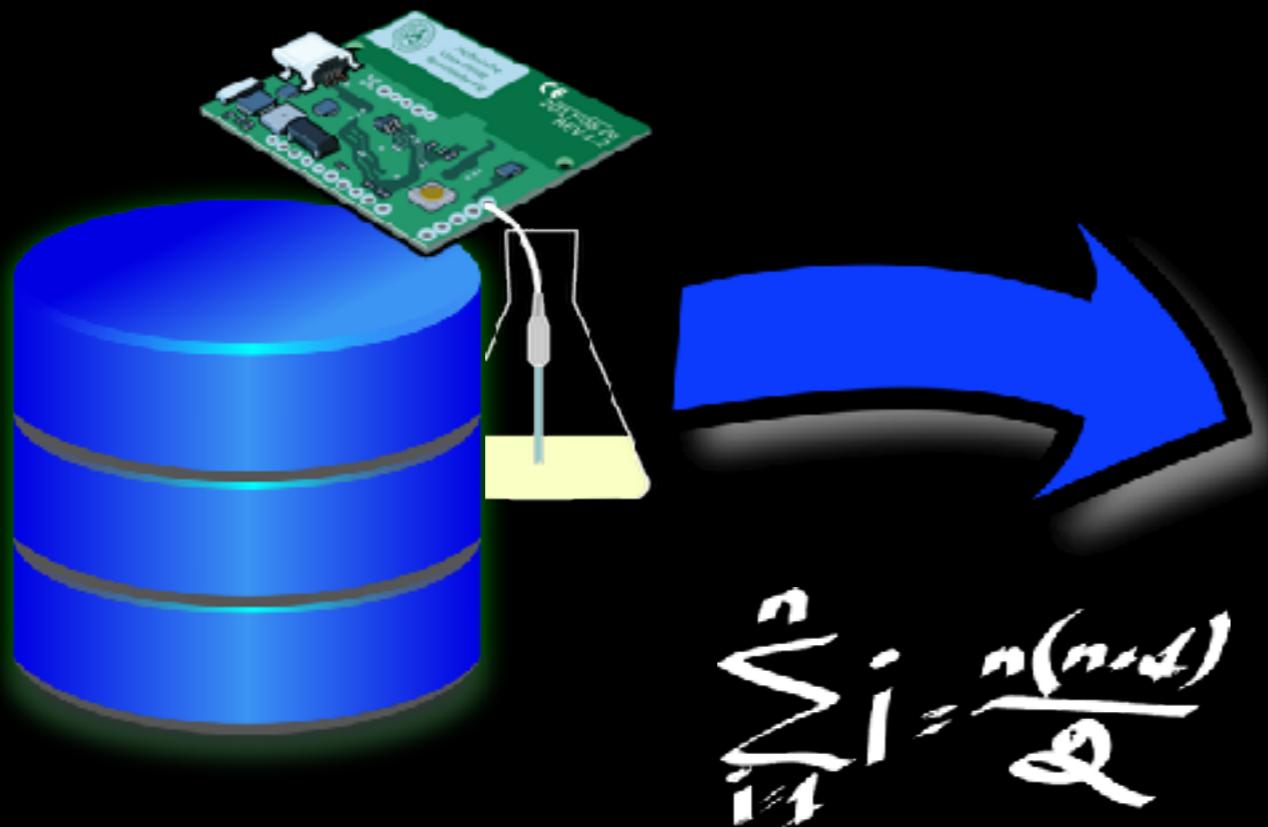


JPG | EPS | SVG

 Herunterladen

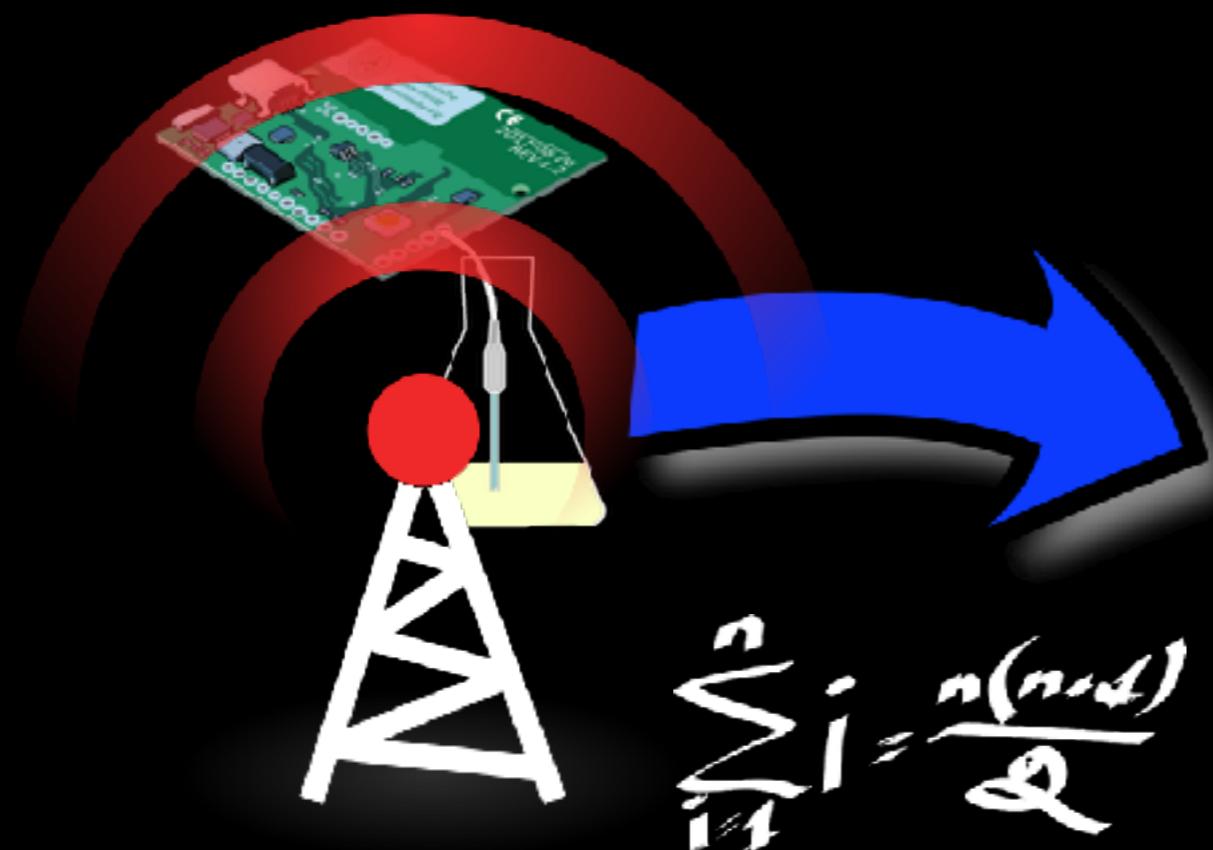
## QRCode einbetten

# Machine Learning on historic data



Source: [deeplearning4j.org](http://deeplearning4j.org)

# Online Learning



Source: [deeplearning4j.org](http://deeplearning4j.org)

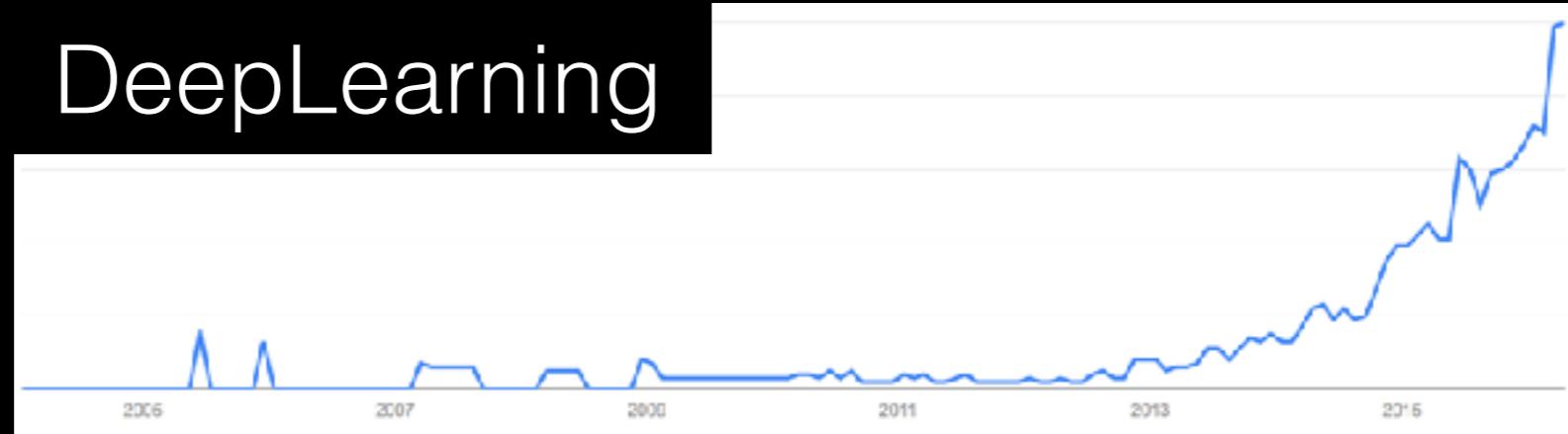
# online vs. historic

- Pros
    - **low storage costs**
    - **real-time model update**
  - Cons
    - **algorithm support**
    - **software support**
    - **no algorithmic improvement**
    - **compute power to be inline with data rate**
- 
- Pros
    - **all algorithms**
    - **abundance of software**
    - **model re-scoring / re-parameterisation (algorithmic improvement)**
    - **batch processing**
  - Cons
    - **high storage costs**
    - **batch model update**

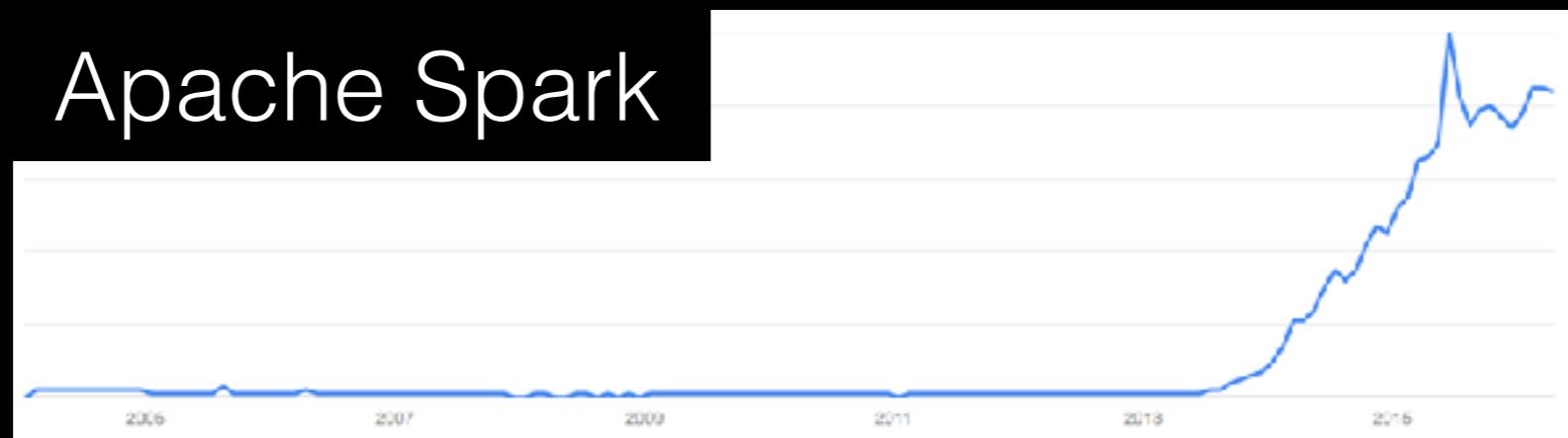
$$\hat{y}_t = \mu + \phi_1 y_{t-1} + \dots + \phi_p y_{t-p} - \theta_1 e_{t-1} - \dots - \theta_q e_{t-q}$$

# DeepLearning

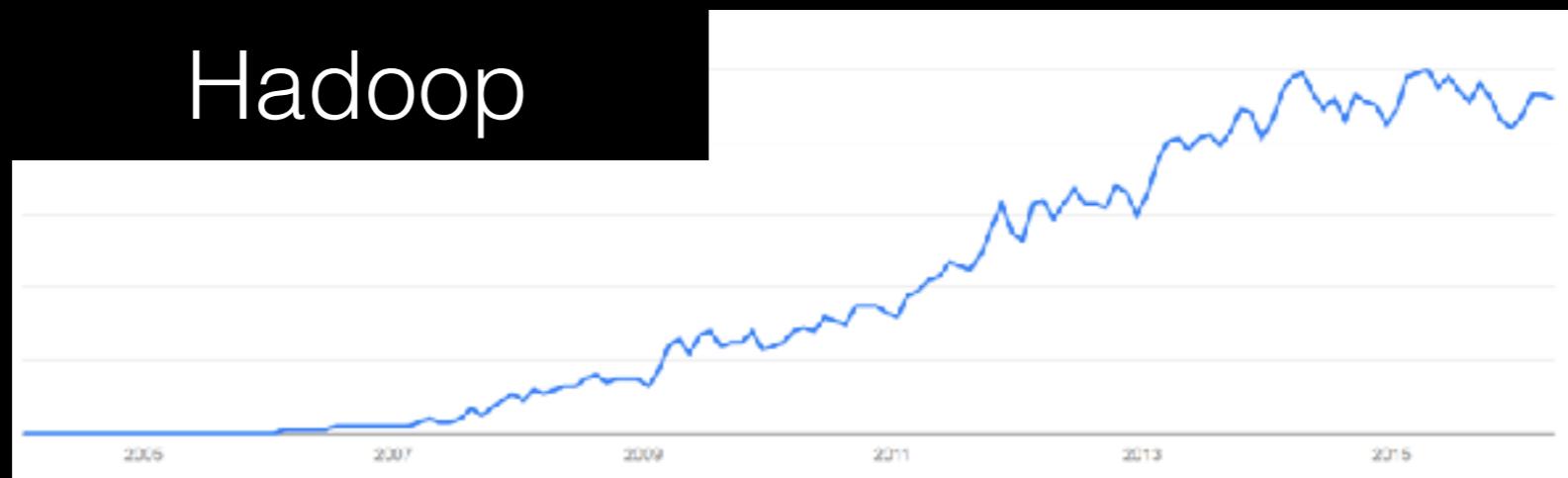
DeepLearning



Apache Spark



Hadoop



# Neural Networks

Part No.	Max Temp. 1	Min Temp 1	Max Vibration 1	Outcome
100	35	35	12	1
101	46	35	21	1
130	56	46	3412	0

# Neural Networks

Part No.	Max Temp. 1	Min Temp 1	Max Vibration 1	Outcome
100	35	35	12	1
101	46	35	21	1
130	56	46	3412	0

```
def predict(datapoint):
    if datapoint.MaxVibration1>100:
        return 0
    else:
        return 1
```

# Neural Networks

Part No.	Max Temp. 1	Min Temp 1	Max Vibration 1	Outcome
100	35	35	12	1
101	46	35	21	1
130	56	46	3412	0

```
def predict(dp):
    return a+b*dp.MaxTemp1+c*dp.MinTemp1+d*dp.MaxVibration1
```

# Neural Networks

Part No.	Max Temp. 1	Min Temp 1	Max Vibration 1	Outcome
100	35	35	12	1
101	46	35	21	1
130	56	46	3412	0

```
import math

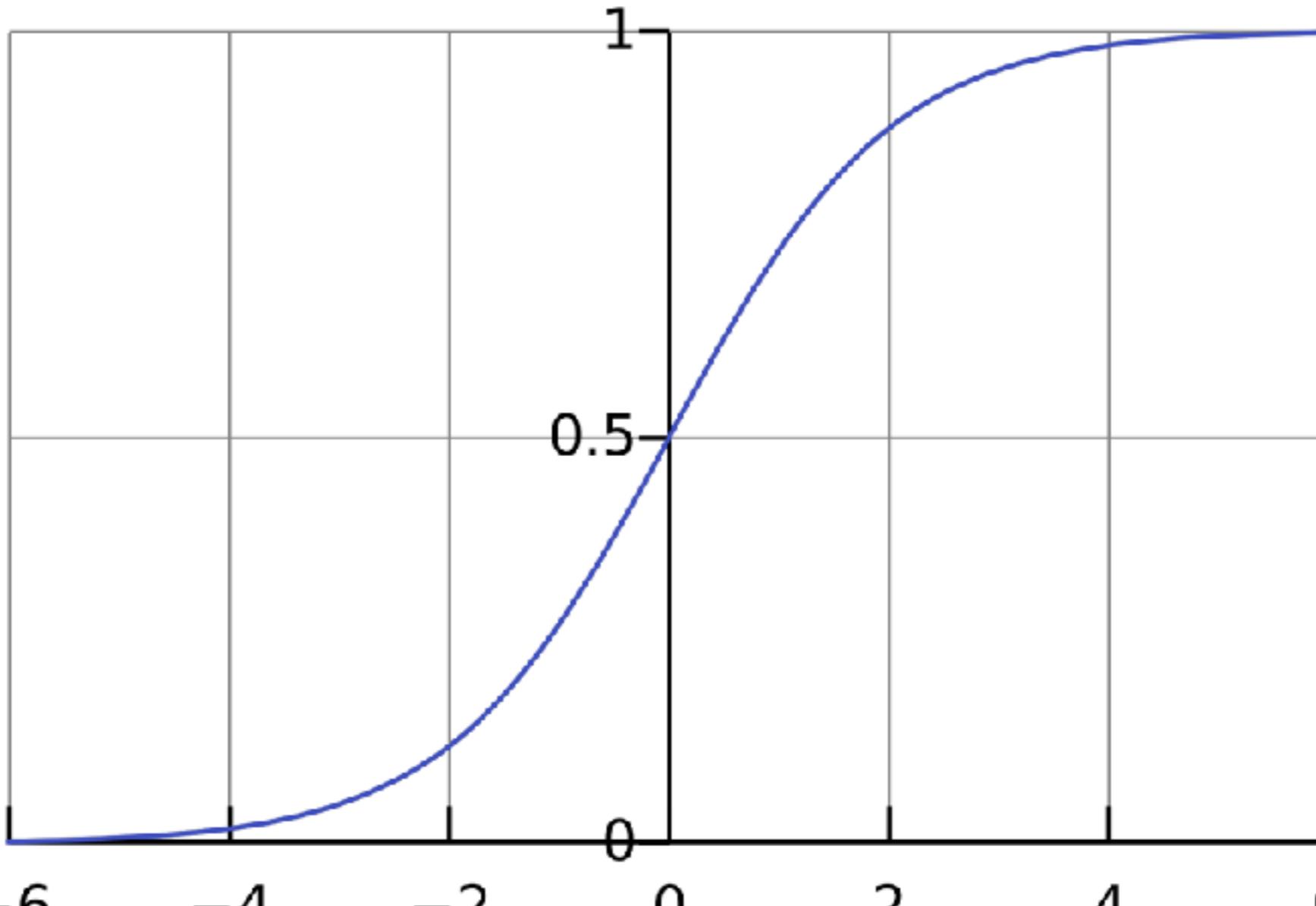
def sigmoid(x):
    return 1 / (1 + math.exp(-x))

def predict(dp):
    return sigmoid(a+b*dp.MaxTemp1+c*dp.MinTemp1+d*dp.MaxVibration1)
```

# Neural Networks

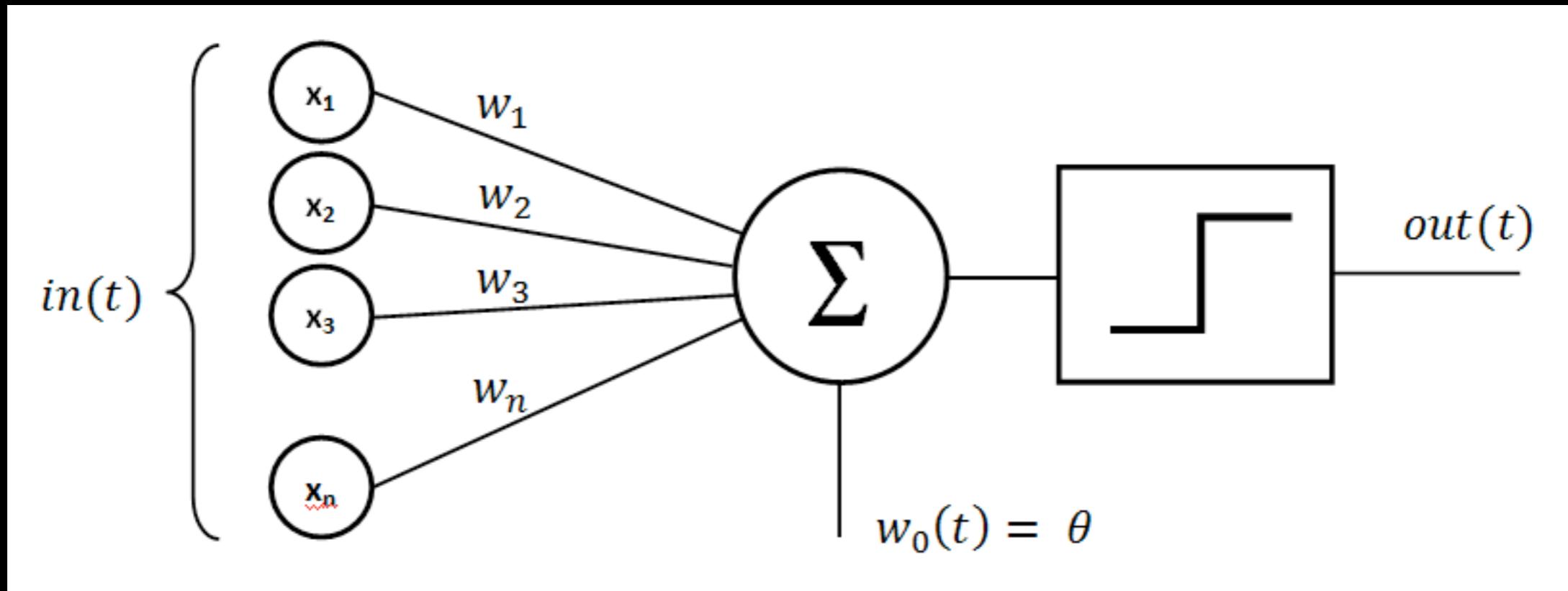
Part No.
100
101
130

```
import math  
  
def sigmoid(x):  
    return 1 / (1 + math.exp(-x))  
  
def predict(dp):  
    return sigmoid(a+b*dp.MaxTemp1+c*dp.MinTemp1+d*dp.MaxVibration1)
```

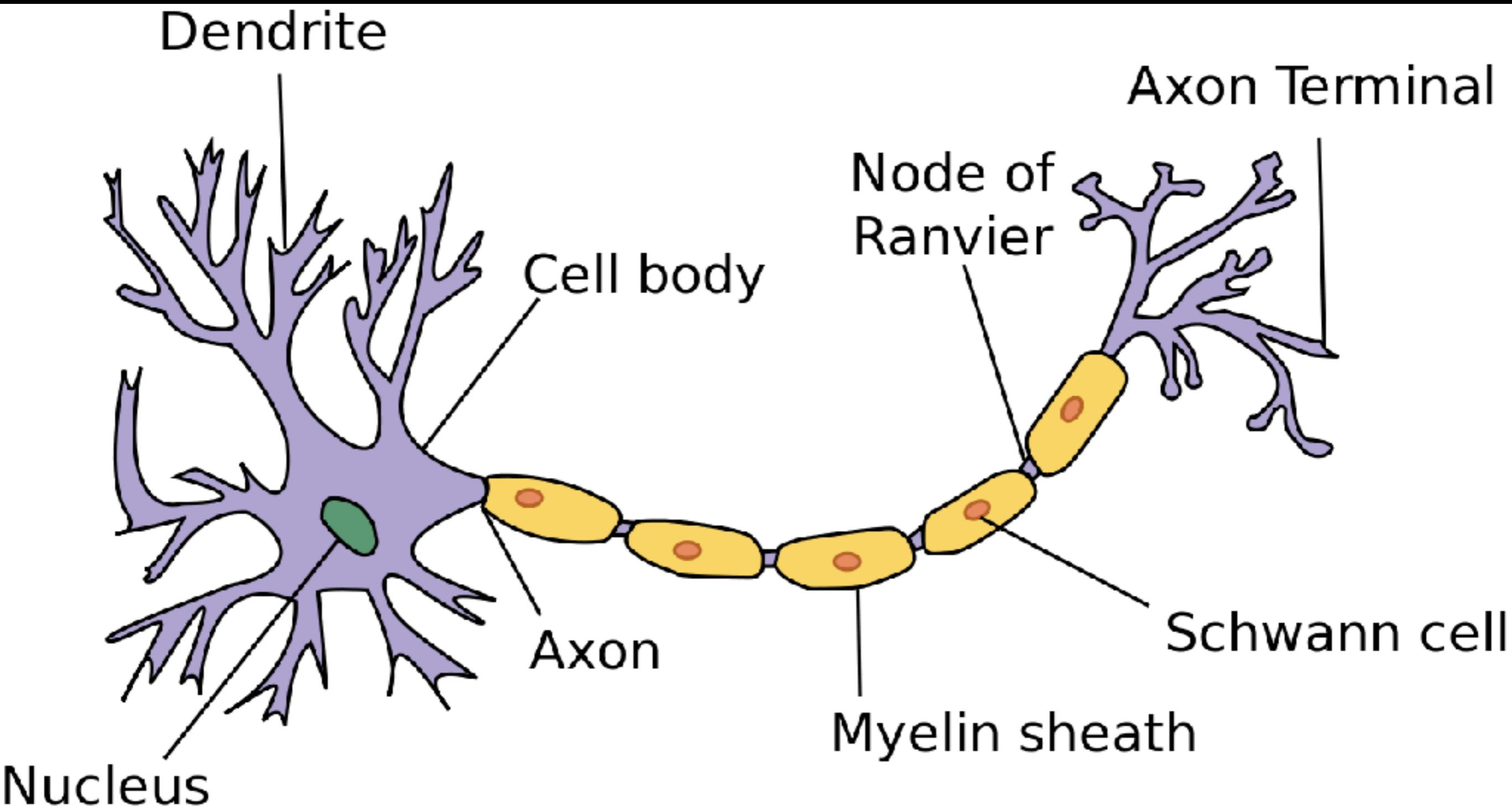


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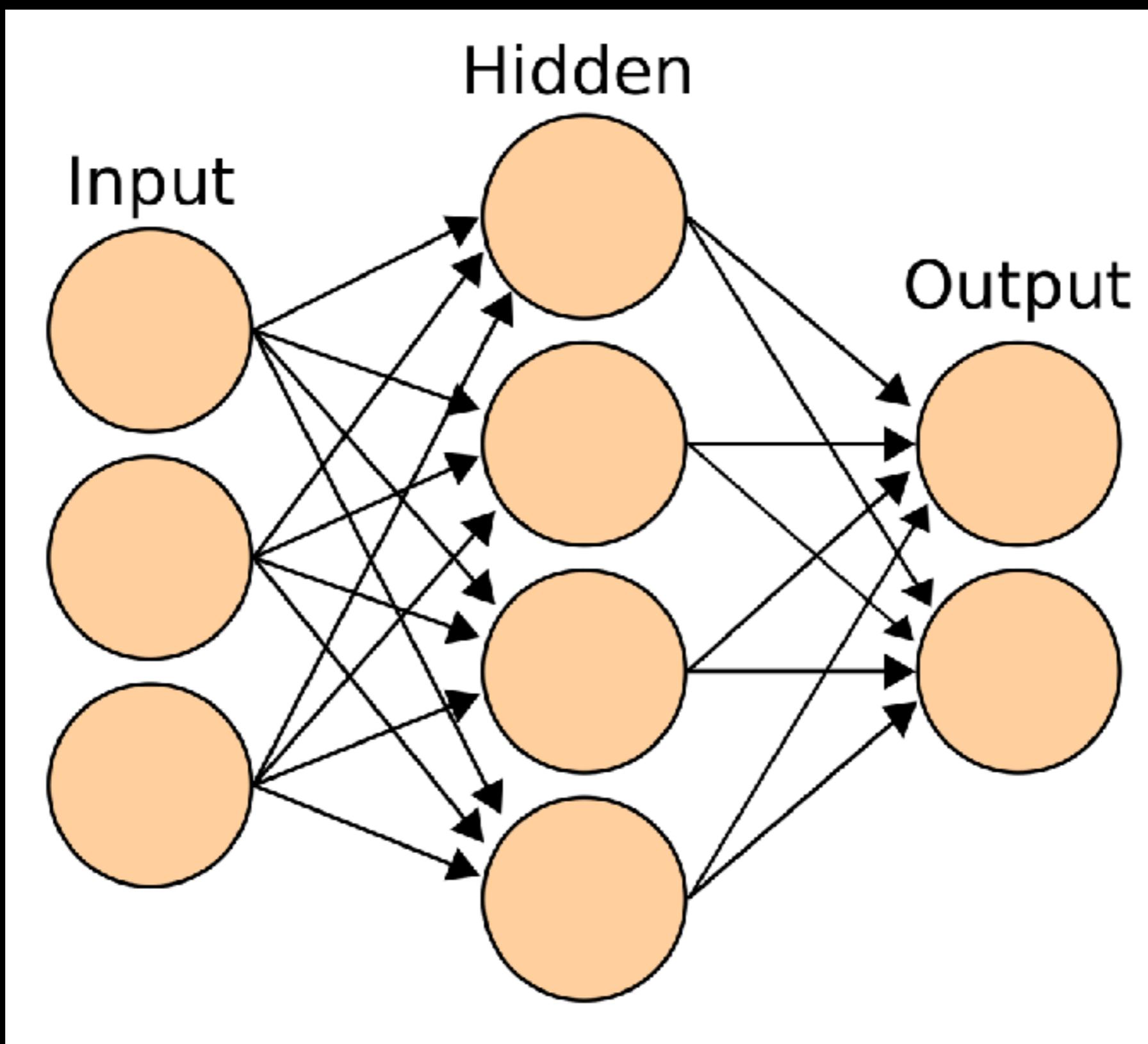
# Neural Networks



# Neural Networks



# Neural Networks



# Neural Networks

```
import numpy as np

datapoint = {"MaxTemp1":35, "MinTemp1":35, "MaxVibration1":12}

#randomly initialize weights
w_layer1 = np.random.rand(4)

def neuron1(dp):
    x = np.array([1,dp["MaxTemp1"],dp["MinTemp1"],dp["MaxVibration1"]])
    return sigmoid(x.dot(w_layer1))

print(neuron1(datapoint))
```

# Neural Networks

```
import numpy as np

#make sigmoid function applicable to vectors instead of scalars only
def sigmoid(z):
    s = 1.0 / (1.0 + np.exp(-1.0 * z))
    return s

datapoint = {"MaxTemp1":35, "MinTemp1":35, "MaxVibration1":12}

#randomly initialize weights, now as a matrix for the four hidden layer neurons
w_layer1 = np.random.rand(4,4)

def layer1(dp):
    x = np.array([1,dp["MaxTemp1"],dp["MinTemp1"],dp["MaxVibration1"]])
    return sigmoid(x.dot(w_layer1))

print(layer1(datapoint))
```

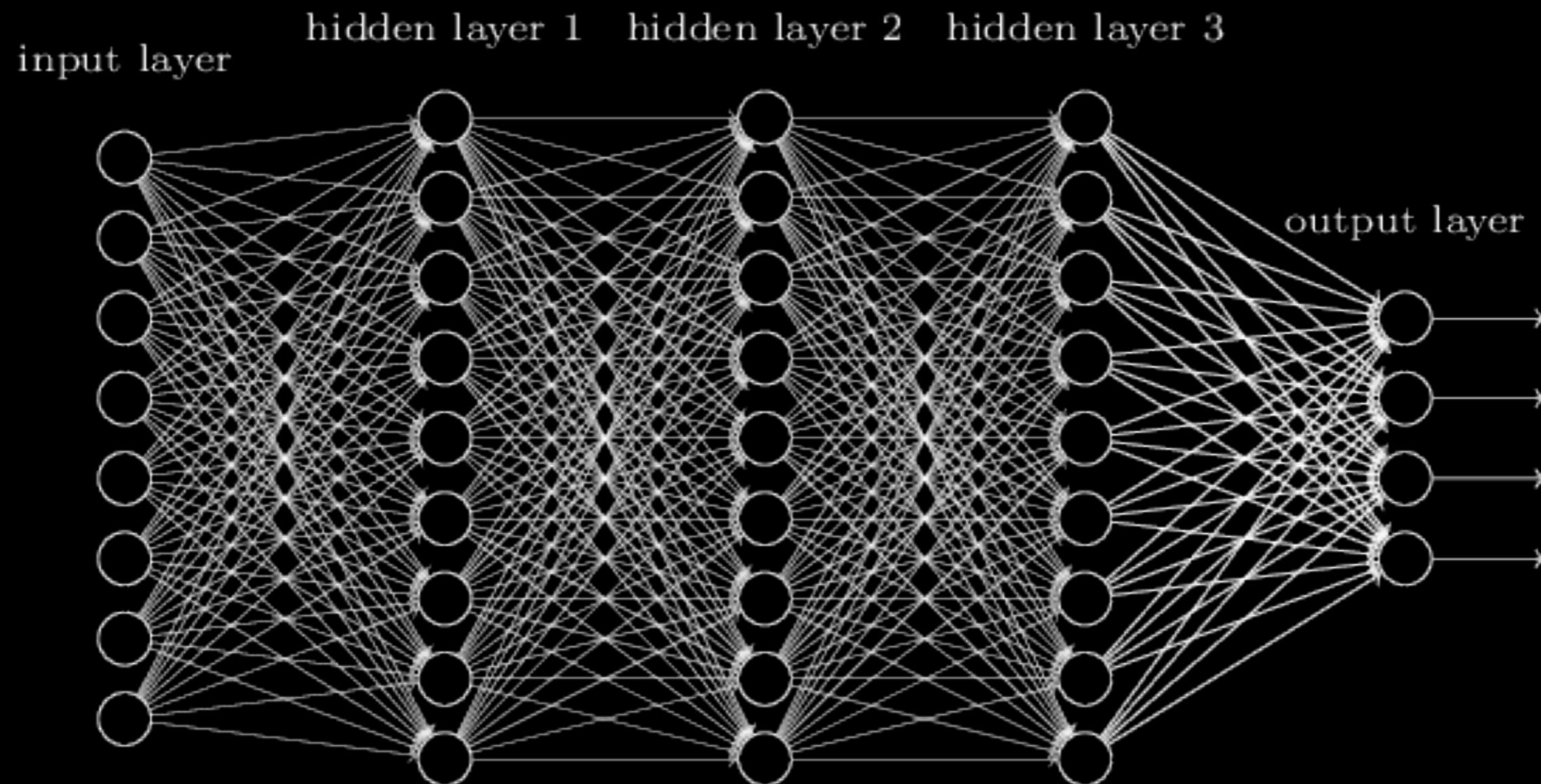
# Neural Networks

```
w_layer2 = np.random.rand(5,2)

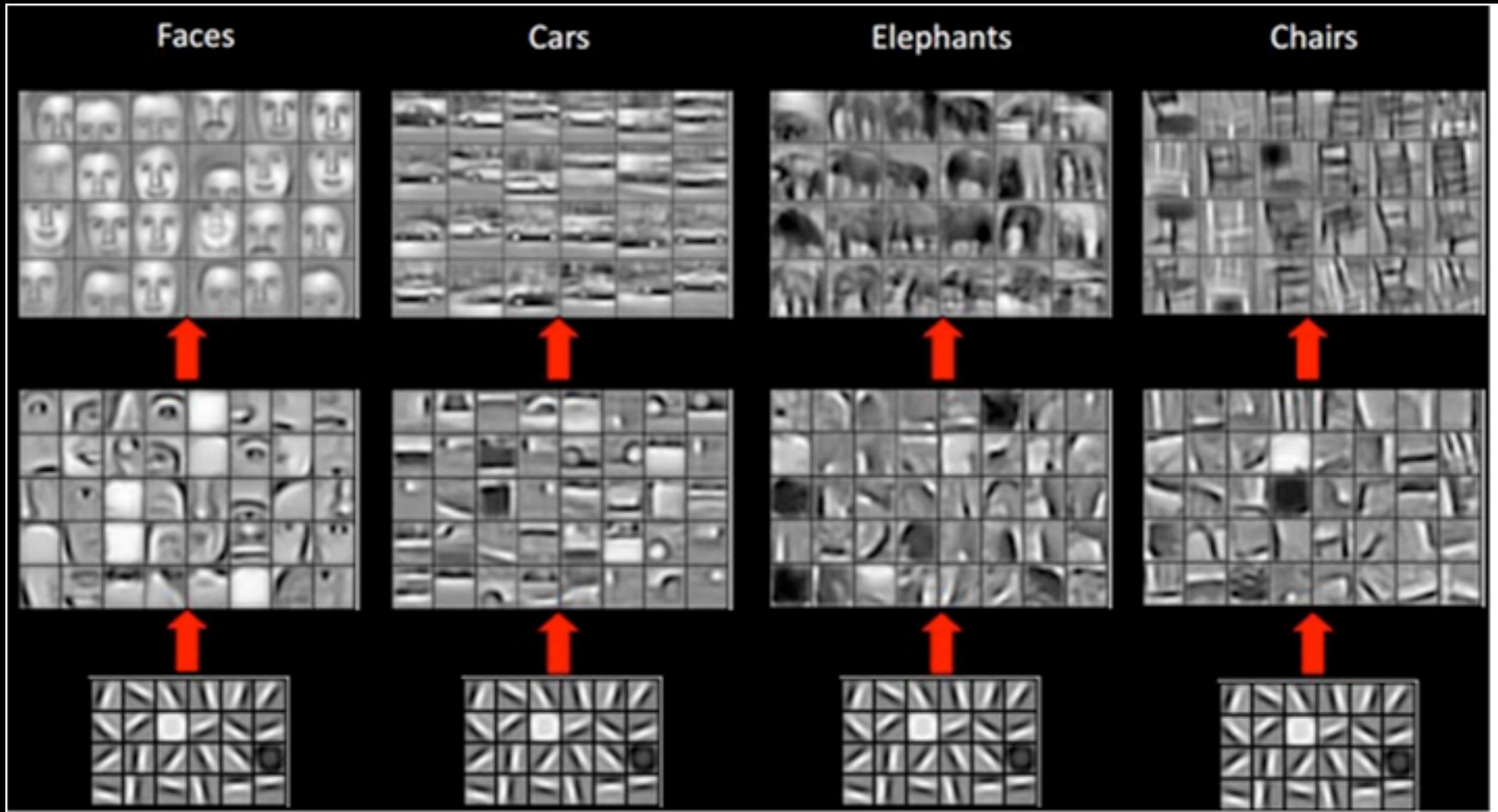
def layer2(x):
    x = np.concatenate(([1],x))
    return sigmoid(x.dot(w_layer2))

print(layer2(layer1(datapoint)))
```

# Deeper (more) Layers



# Convolutional



# Convolutional



+

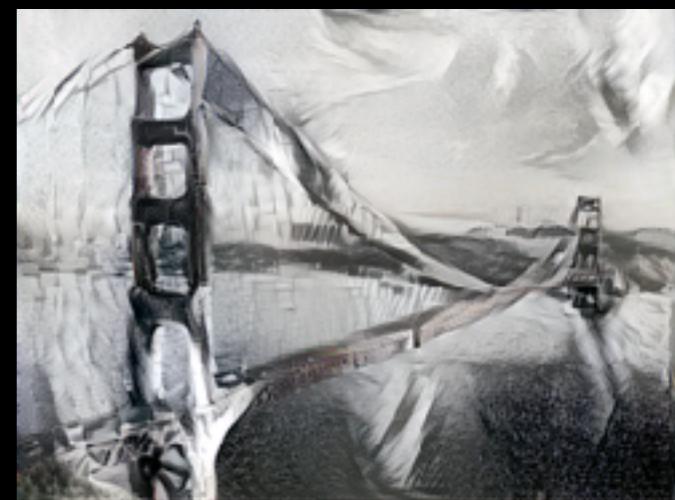
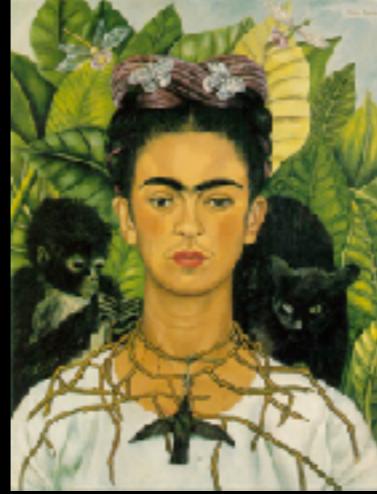


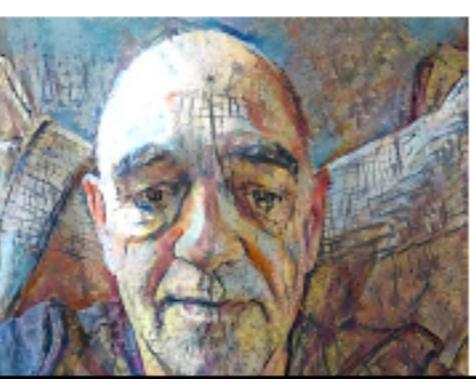
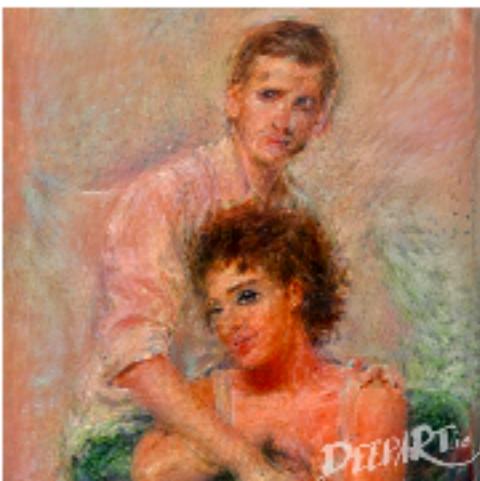
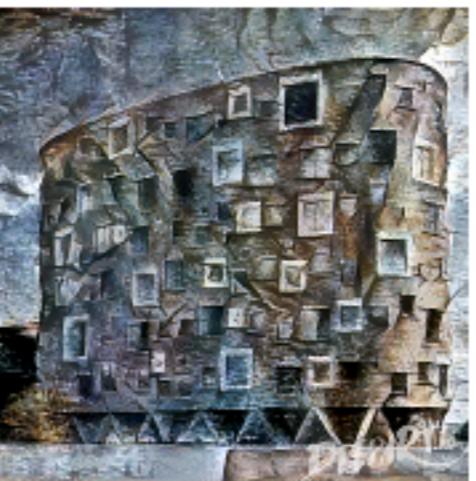
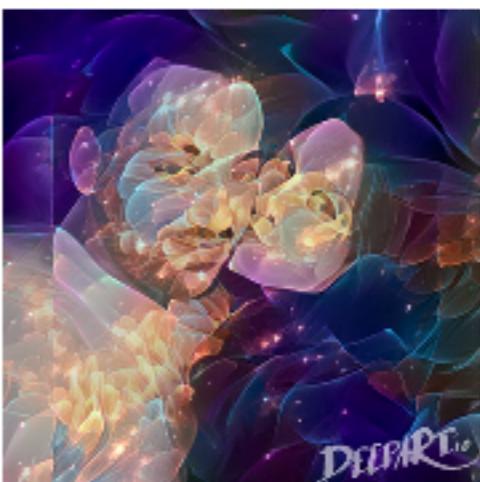
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DEEPART

# Convolutional

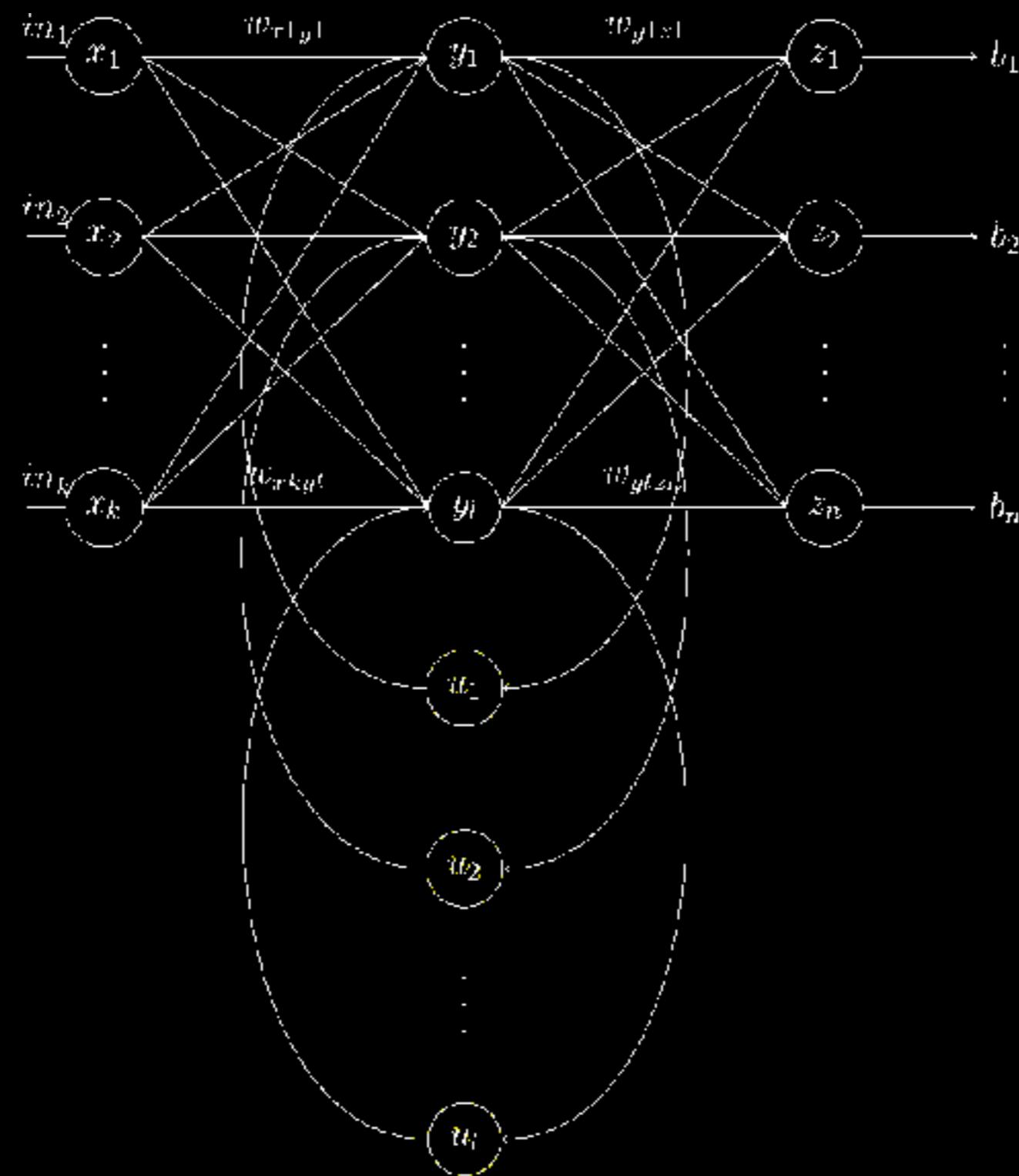




# Learning of a function

*A neural network can basically learn any mathematical function*

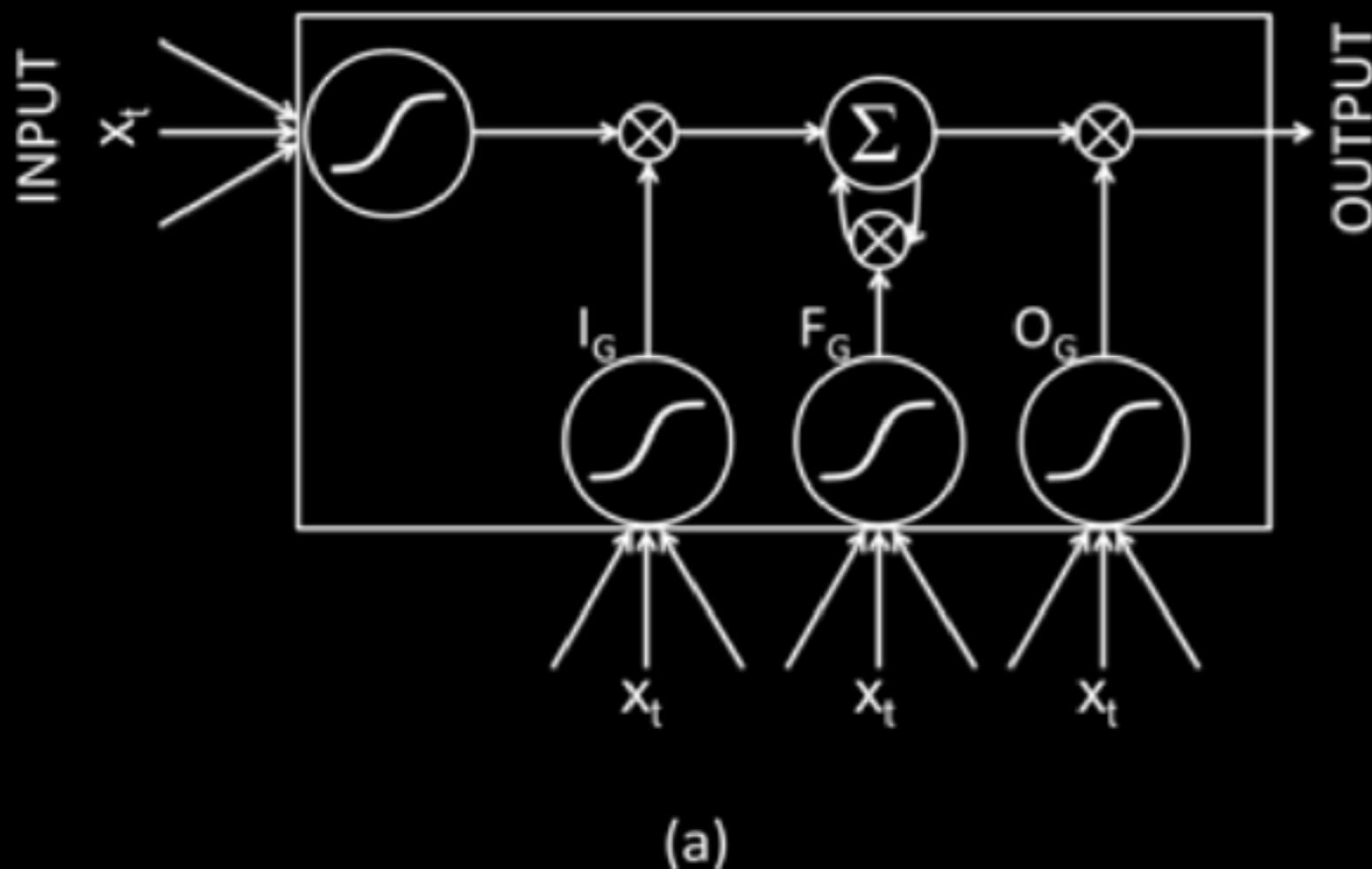
# Recurrent



<http://www.theverge.com/2015/7/17/8985699/stanford-neural-networks-image-recognition-google-study>

<http://www.media.uzh.ch/en/Press-Releases/2016/drohnen-suchen-selbststaendig-auf-waldwegen-nach-vermissten-.html>

# LSTM



“vanishing gradient problem” == influence of past inputs decay quickly over time

PANDARUS:

Alas, I think he shall be come approached and the day  
When little strain would be attain'd into being never fed,  
And who is but a chain and subjects of his death,  
I should not sleep.

Second Senator:

They are away this miseries, produced upon my soul,  
Breaking and strongly should be buried, when I perish  
The earth and thoughts of many states.

DUKE VINCENTIO:

Well, your wit is in the care of side and that.

Second Lord:

They would be ruled after this chamber, and  
my fair nues begun out of the fact, to be conveyed,  
Whose noble souls I'll have the heart of the wars.

Clown:

Come, sir, I will make did behold your worship.

VIOLA:

I'll drink it.

VIOLA:

Why, Salisbury must find his flesh and thought  
That which I am not aps, not a man and in fire,  
To show the reining of the raven and the wars  
To grace my hand reproach within, and not a fair are hand,  
That Caesar and my goodly father's world;  
When I was heaven of presence and our fleets,  
We spare with hours, but cut thy council I am great,  
Murdered and by thy master's ready there  
My power to give thee but so much as hell:  
Some service in the noble bondman here,  
Would show him to her wine.

KING LEAR:

O, if you were a feeble sight, the courtesy of your law,  
Your sight and several breath, will wear the gods  
With his heads, and my hands are wonder'd at the deeds,  
So drop upon your lordship's head, and your opinion  
Shall be against your honour.

For  $\bigoplus_{n=1,\dots,m} \mathcal{L}_{m,n} = 0$ , hence we can find a closed subset  $\mathcal{H}$  in  $\mathcal{H}$  and any sets  $\mathcal{F}$  on  $X$ ,  $U$  is a closed immersion of  $S$ , then  $U \rightarrow T$  is a separated algebraic space.

*Proof.* Proof of (1). It also start we get

$$S = \text{Spec}(R) = U \times_X U \times_X U$$

and the comparicoly in the fibre product covering we have to prove the lemma generated by  $\coprod Z \times_U U \rightarrow V$ . Consider the maps  $M$  along the set of points  $\text{Sch}_{fppf}$  and  $U \rightarrow U$  is the fibre category of  $S$  in  $U$  in Section, ?? and the fact that any  $U$  affine, see Morphisms, Lemma ???. Hence we obtain a scheme  $S$  and any open subset  $W \subset U$  in  $\text{Sh}(G)$  such that  $\text{Spec}(R') \rightarrow S$  is smooth or an

$$U = \bigcup U_i \times_{S_i} U_i$$

which has a nonzero morphism we may assume that  $f_i$  is of finite presentation over  $S$ . We claim that  $\mathcal{O}_{X,x}$  is a scheme where  $x, x', s'' \in S'$  such that  $\mathcal{O}_{X,x'} \rightarrow \mathcal{O}'_{X',x'}$  is separated. By Algebra, Lemma ?? we can define a map of complexes  $\text{GL}_{S'}(x'/S'')$  and we win.  $\square$

To prove study we see that  $\mathcal{F}|_U$  is a covering of  $X'$ , and  $\mathcal{T}_i$  is an object of  $\mathcal{F}_{X/S}$  for  $i > 0$  and  $\mathcal{F}_p$  exists and let  $\mathcal{F}_i$  be a presheaf of  $\mathcal{O}_X$ -modules on  $\mathcal{C}$  as a  $\mathcal{F}$ -module. In particular  $\mathcal{F} = U/\mathcal{F}$  we have to show that

$$\widetilde{M}^\bullet = \mathcal{I}^\bullet \otimes_{\text{Spec}(k)} \mathcal{O}_{S,s} - i_X^{-1} \mathcal{F}$$

is a unique morphism of algebraic stacks. Note that

$$\text{Arrows} = (\text{Sch}/S)^{\text{opp}}_{fppf}, (\text{Sch}/S)_{fppf}$$

and

$$V = \Gamma(S, \mathcal{O}) \longrightarrow (U, \text{Spec}(A))$$

is an open subset of  $X$ . Thus  $U$  is affine. This is a continuous map of  $X$  is the inverse, the groupoid scheme  $S$ .

*Proof.* See discussion of sheaves of sets.  $\square$

The result for prove any open covering follows from the less of Example ???. It may replace  $S$  by  $X_{\text{spaces},\text{etale}}$  which gives an open subspace of  $X$  and  $T$  equal to  $S_{\text{Zar}}$ , see Descent, Lemma ???. Namely, by Lemma ?? we see that  $R$  is geometrically regular over  $S$ .

**Lemma 0.1.** Assume (3) and (3) by the construction in the description.

Suppose  $X = \lim |X|$  (by the formal open covering  $X$  and a single map  $\underline{\text{Proj}}_X(\mathcal{A}) = \text{Spec}(B)$  over  $U$  compatible with the complex

$$\text{Set}(\mathcal{A}) = \Gamma(X, \mathcal{O}_{X,\mathcal{O}_X}).$$

When in this case of to show that  $\mathcal{Q} \rightarrow \mathcal{C}_{Z/X}$  is stable under the following result in the second conditions of (1), and (3). This finishes the proof. By Definition ?? (without element is when the closed subschemes are catenary. If  $T$  is surjective we may assume that  $T$  is connected with residue fields of  $S$ . Moreover there exists a closed subspace  $Z \subset X$  of  $X$  where  $U$  in  $X'$  is proper (some defining as a closed subset of the uniqueness it suffices to check the fact that the following theorem

(1)  $f$  is locally of finite type. Since  $S = \text{Spec}(R)$  and  $Y = \text{Spec}(R)$ .

*Proof.* This is form all sheaves of sheaves on  $X$ . But given a scheme  $U$  and a surjective étale morphism  $U \rightarrow X$ . Let  $U \cap U = \coprod_{i=1,\dots,n} U_i$  be the scheme  $X$  over  $S$  at the schemes  $X_i \rightarrow X$  and  $U = \lim_i X_i$ .  $\square$

The following lemma surjective restrocomposes of this implies that  $\mathcal{F}_{x_0} = \mathcal{F}_{x_0} = \mathcal{F}_{X,\dots,x_0}$ .

**Lemma 0.2.** Let  $X$  be a locally Noetherian scheme over  $S$ ,  $E = \mathcal{F}_{X/S}$ . Set  $\mathcal{I} = \mathcal{J}_1 \subset \mathcal{I}'_n$ . Since  $\mathcal{I}'_n \subset \mathcal{I}^n$  are nonzero over  $i_0 \leq p$  is a subset of  $\mathcal{J}_{n,0} \circ \overline{A}_2$  works.

**Lemma 0.3.** In Situation ???. Hence we may assume  $q' = 0$ .

*Proof.* We will use the property we see that  $p$  is the next functor (??). On the other hand, by Lemma ?? we see that

$$D(\mathcal{O}_{X'}) = \mathcal{O}_X(D)$$

where  $K$  is an  $F$ -algebra where  $\delta_{n+1}$  is a scheme over  $S$ .  $\square$

```
/*
 * Increment the size file of the new incorrect UI_FILTER group information
 * of the size generatively.
 */

static int indicate_policy(void)
{
    int error;
    if (fd == MARN_EPT) {
        /*
         * The kernel blank will coeld it to userspace.
         */
        if (ss->segment < mem_total)
            unblock_graph_and_set_blocked();
        else
            ret = 1;
        goto bail;
    }
    segaddr = in_SB(in.addr);
    selector = seg / 16;
    setup_works = true;
    for (i = 0; i < blocks; i++) {
        seq = buf[i++];
        bpf = bd->bd.next + i * search;
        if (fd) {
            current = blocked;
        }
    }
    rw->name = "Getjbbregs";
    bprm_self_clearl(&iv->version);
    regs->new = blocks[(BPF_STATS << info->historidac)] | PFMR_CLOBATHINC_SECONDS << 12;
    return segtable;
}
```

<https://m.soundcloud.com/optometrist-prime/recurrence-music-written-by-a-recurrent-neural-network>

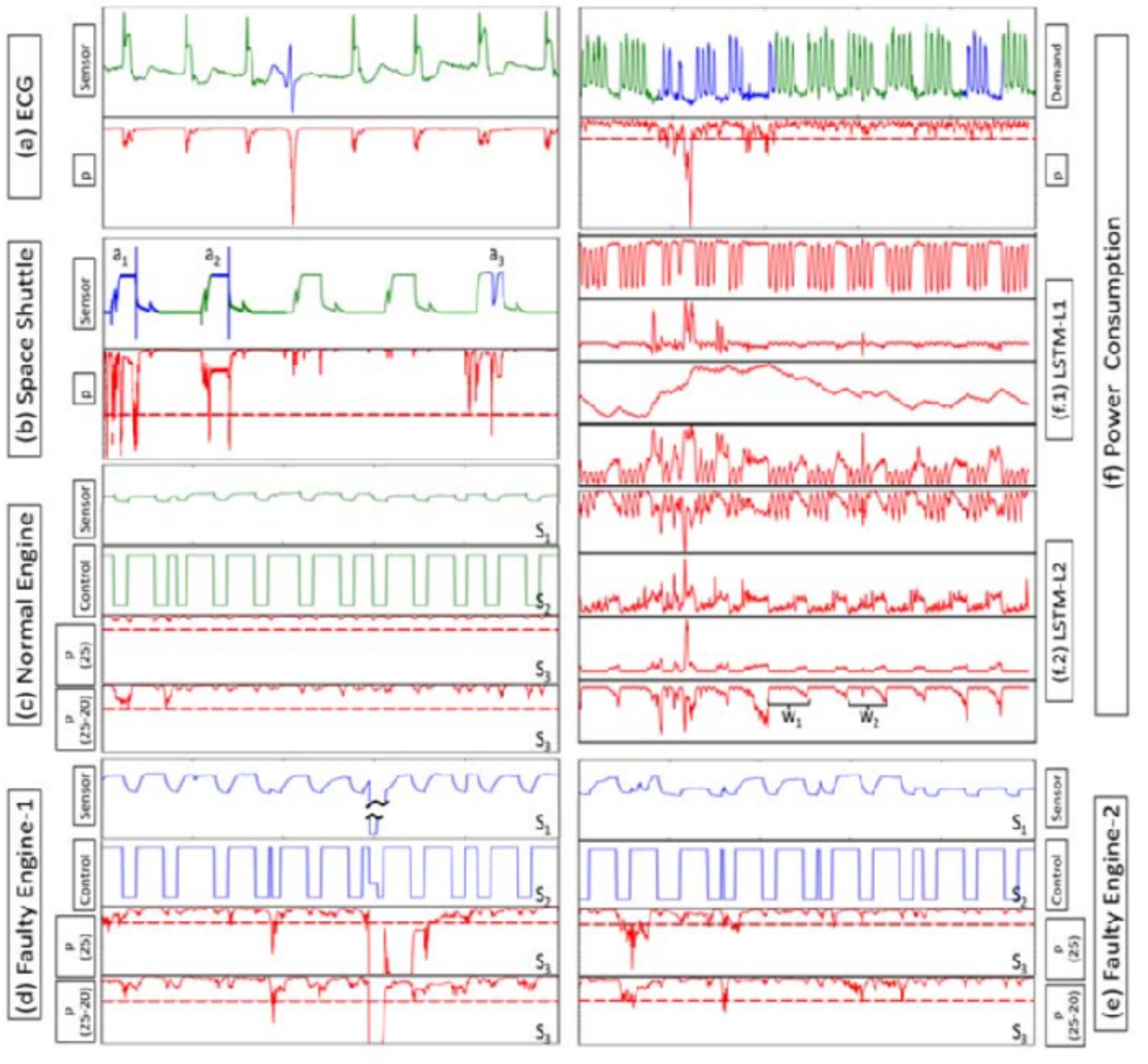
# Long Short Term Memory Networks for Anomaly Detection in Time Series

Pankaj Malhotra<sup>1</sup>, Lovekesh Vig<sup>2</sup>, Gautam Shroff<sup>1</sup>, Puneet Agarwal<sup>1</sup>

1- TCS Research, Delhi, India

2- Jawaharlal Nehru University, New Delhi, India

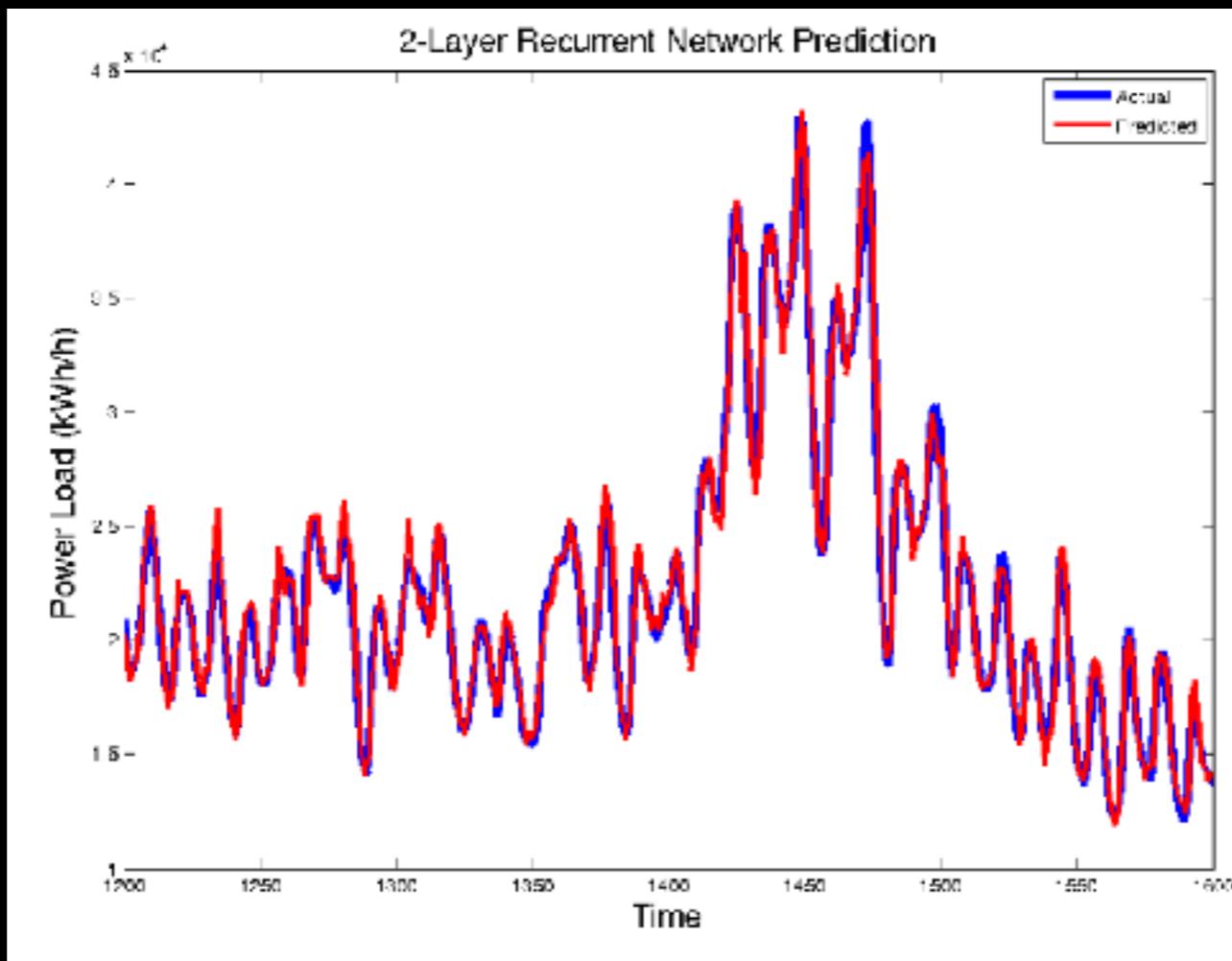
- Outperformed traditional methods, such as
  - cumulative sum (CUSUM)
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  - Hidden Markov Models (HMM)
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Learning Method	RMSE	% RMSE
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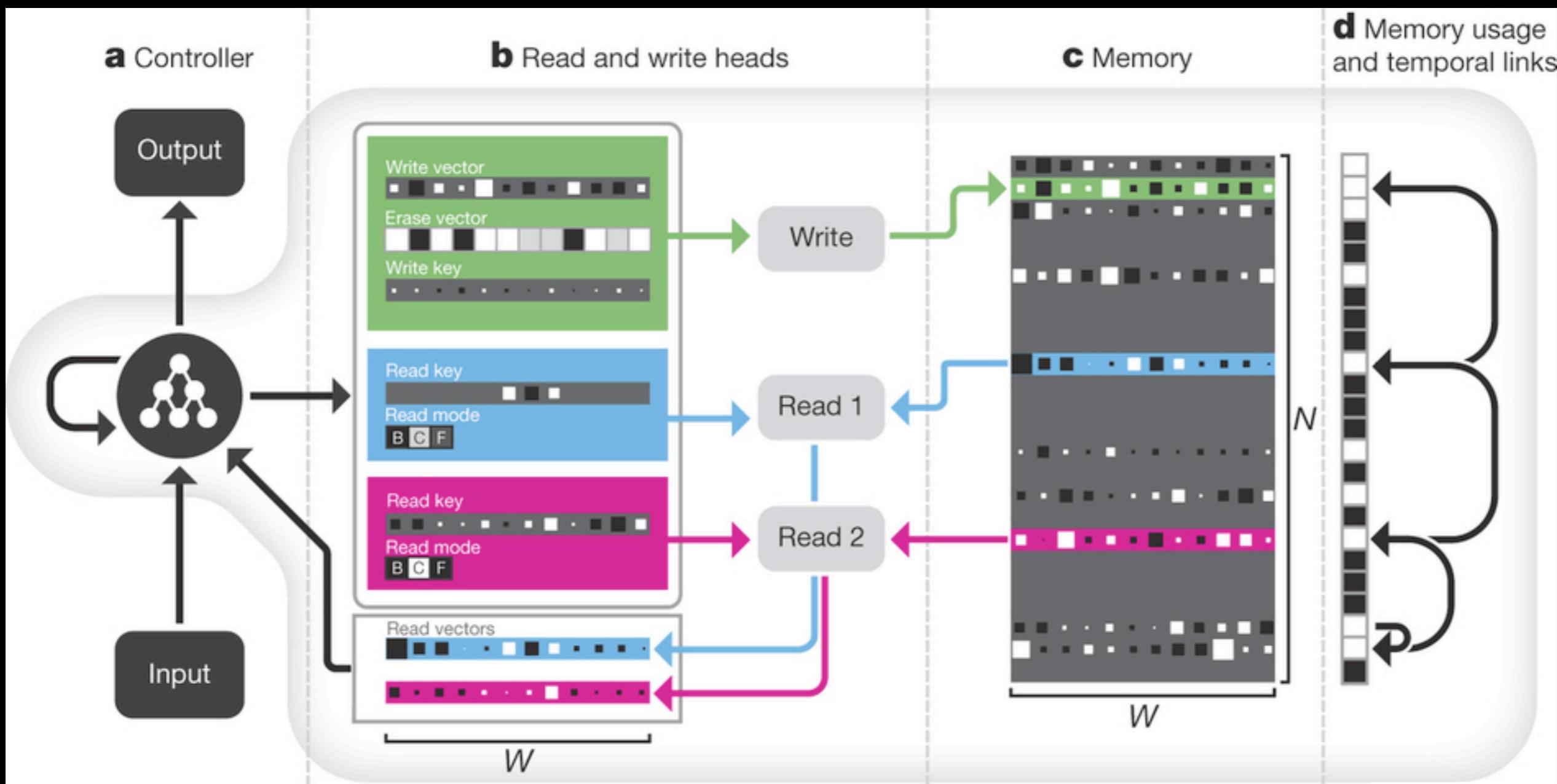
# Learning of an algorithm

*A LSTM network is Turing complete<sup>1</sup>*

1: [http://binds.cs.umass.edu/papers/1995\\_Siegelmann\\_Science.pdf](http://binds.cs.umass.edu/papers/1995_Siegelmann_Science.pdf)

# Learning of an algorithm v2

*The Differentiable Neural Computer*



# Problems

- Neural Networks are computationally very complex
  - especially during training
  - but also during scoring



CPU (2009)



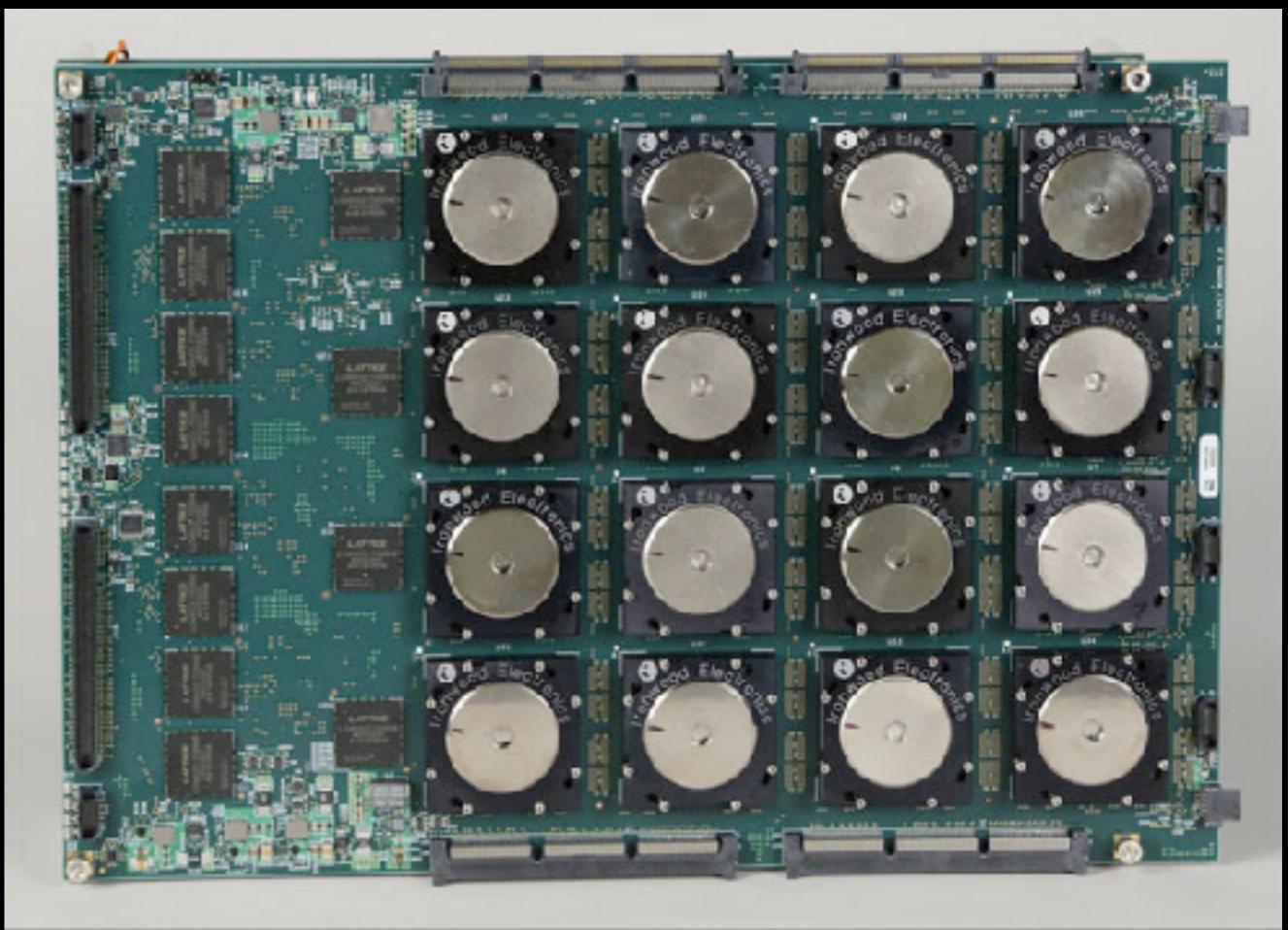
GPU (2016)



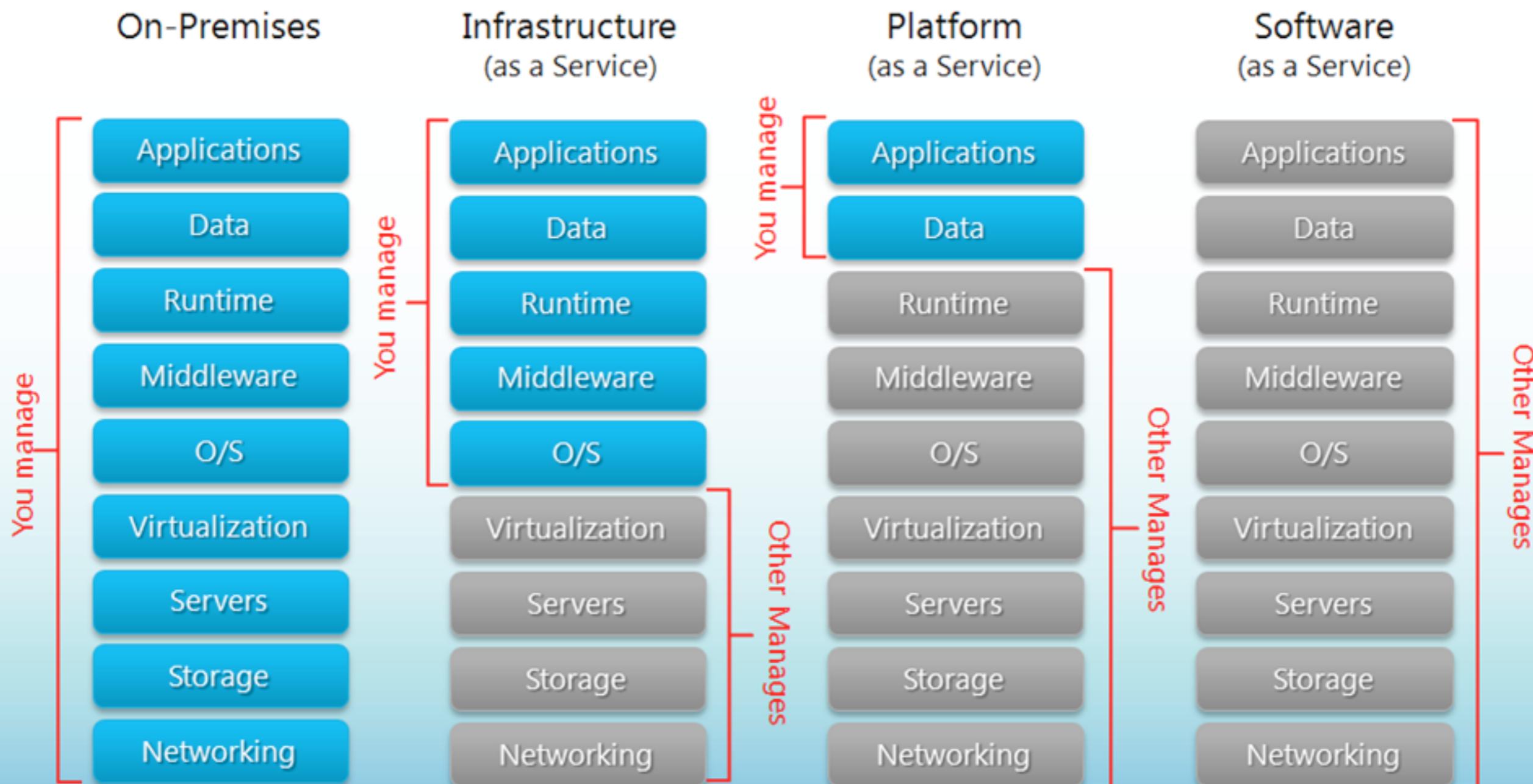
IBM TrueNorth (2017)

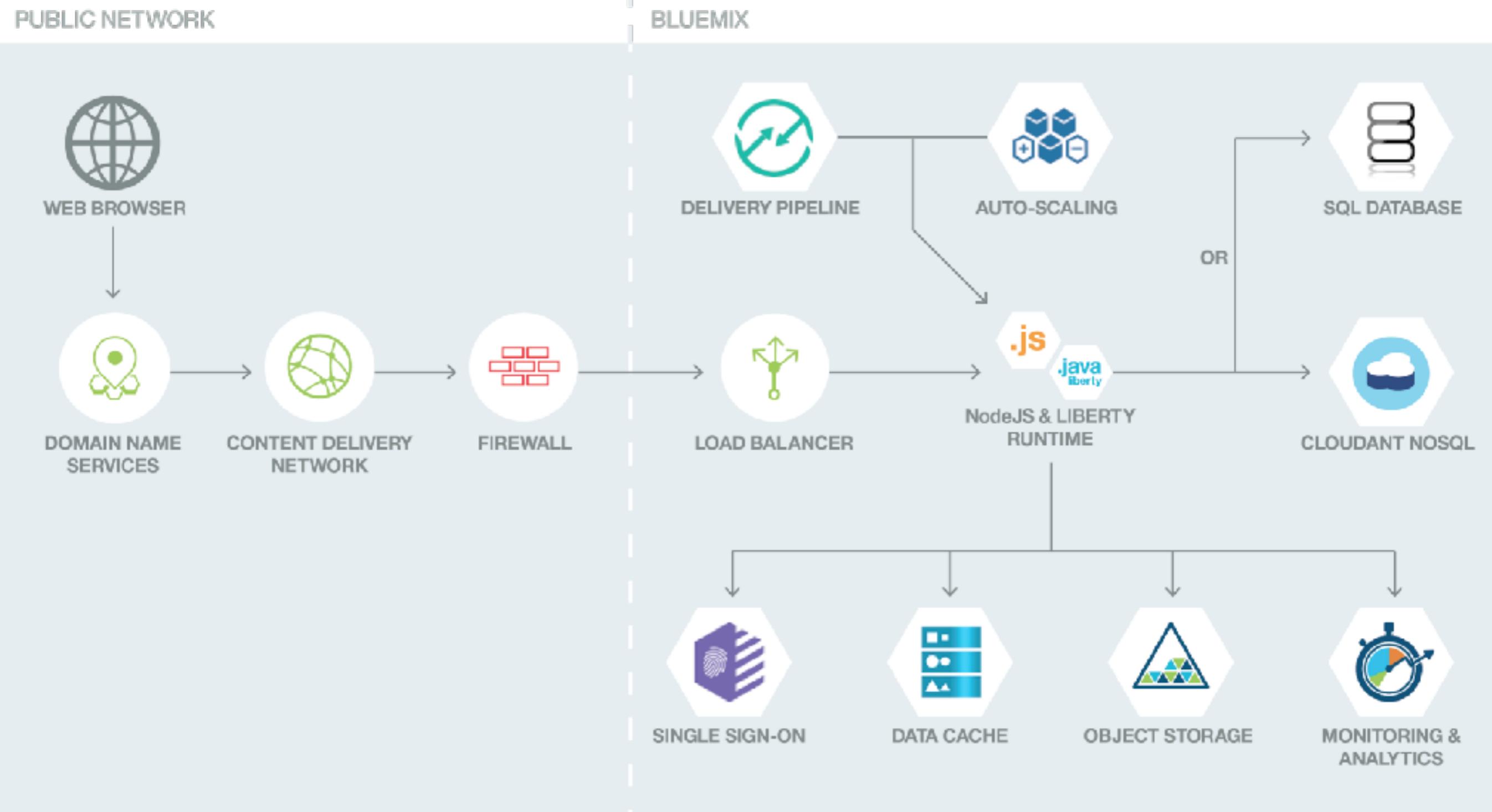
# IBM TrueNorth

- Scalable
- Parallel
- Distributed
- Fault Tolerant
- No Clock ! :)
- IBM Cluster
  - 4.096 chips
  - 4 billion neurons
  - 1 trillion synapses
- Human Brain
  - 100 billion neurons
  - 100 trillion synapses
- 1.000.000 neurons
- 250.000.000 synapses



# Separation of Responsibilities





	<b>Watson IoT</b>	<b>Watson Cognitive Services</b>	<b>Analytics</b>
<b>Model + API</b>	Driver Behaviour	Personality Insights	
<b>Trainable Model + API</b>	IoT for Insurance	Visual Recognition	
<b>Customizable Model + API</b>			Watson Machine Learning
<b>Data Science Platform as a Service</b>			Data Science Experience

# DeepLearning4J

# Components

- DeepLearning4J  
Enterprise Grade DeepLearning Library
- DataVec  
CSV/Audio/Video/Image/... => Vector
- ND4J / ND4S (NumPy for the JVM)

# ND4J

- Tensor support (Linear Buffer + Stride)
- Multiple implementations, one interface
  - vectorized c++ code (JavaCPP), off-heap data storage, BLAS (OpenBLAS, Intel MKL, cuBLAS)
  - GPU (CUDA 7.5)

# turn on GPU

```
<name>DeepLearning4j Examples Parent</name>
<description>Examples of training different data sets</description>
<properties>
    <nd4j.backend>nd4j-native-platform</nd4j.backend>
```

```
<nd4j.backend>nd4j-cuda-7.5-platform</nd4j.backend>
```

# DL4J parallelisation

- TensorFlow on ApacheSpark =>
  - Scoring
  - Multi-model hyper-parameter tuning
  - Parallel training since V r0.8
- DeepLearning4J =>
  - Scoring, Multi-model hyper-parameter tuning
  - Parallel training
    - “Jeff Dean style parameter averaging”

“Code local vs spark”

**new MultiLayerNetwork(conf);**

vs.

**new SparkDl4jMultiLayer(sc, conf, tm);**

```
TrainingMaster tm = new ParameterAveragingTrainingMaster.Builder(int dataSetObjectSize)
    ... (your configuration here)
    .build();
```

# Demo

IoT / Industry / Predictive Maintenance Use Case



Romeo Kienzler @romeokienzler

11:19

@raver119 @agibsonccc One Q. Today evening in my talk I'm planning to state that DL4J is the only FW capable of training NN in Jeff Dean Style Parameter Averaging on ApacheSpark (+ GPU support +support for all sorts of NN topologies) Is this correct? IMHO TensorFrames doesn't support parallel Parameter Averaging , correct?



Adam Gibson @agibsonccc

11:19

yup

so tensorframes only allows ETL



The main thing it had going for it was the catalyst compiler for tensorflow ops

It also hasn't seem a commit since august

We also support configuring everything from a spark job

Tensorframes for their JNI support used javacpp (which we maintain)

So main differences: Community and Distributed



Romeo Kienzler @romeokienzler

11:23

Thanks a lot @agibsonccc



Adam Gibson @agibsonccc

11:23

sure 😊



Alex Black @AlexDBlack

11:28

also tensorframes is based on dataframes, so no variable length data (images, time series etc) afaik



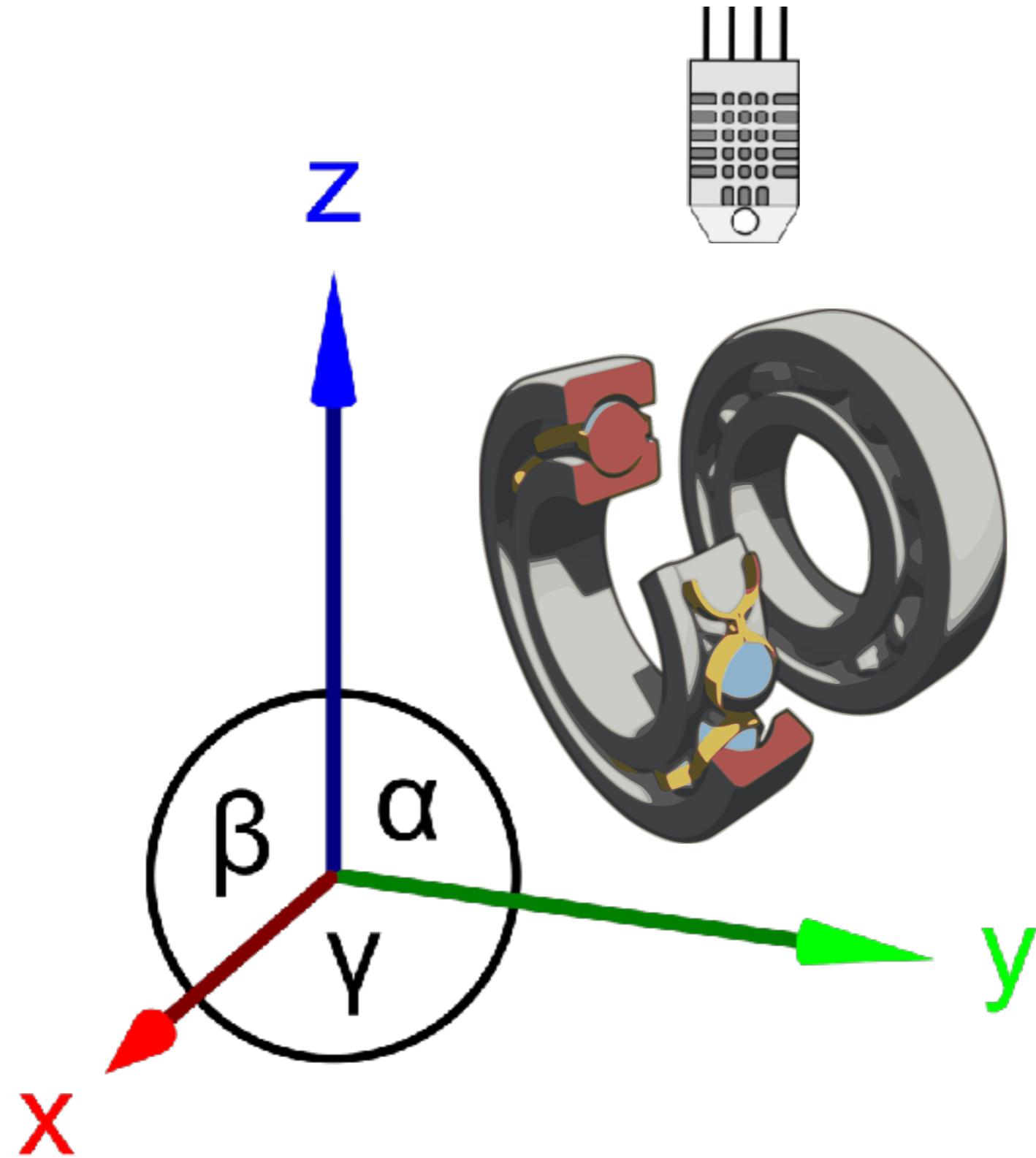
Adam Gibson @agibsonccc

11:44

right

26 UNREAD





# data

Branch: master ▾ New pull request Create new file Upload files Find file Clone or download ▾

Romeo Kienzler Merge branch 'master' of <https://github.com/romeokienzler/pmqsimulator> Latest commit ed14837 24 days ago

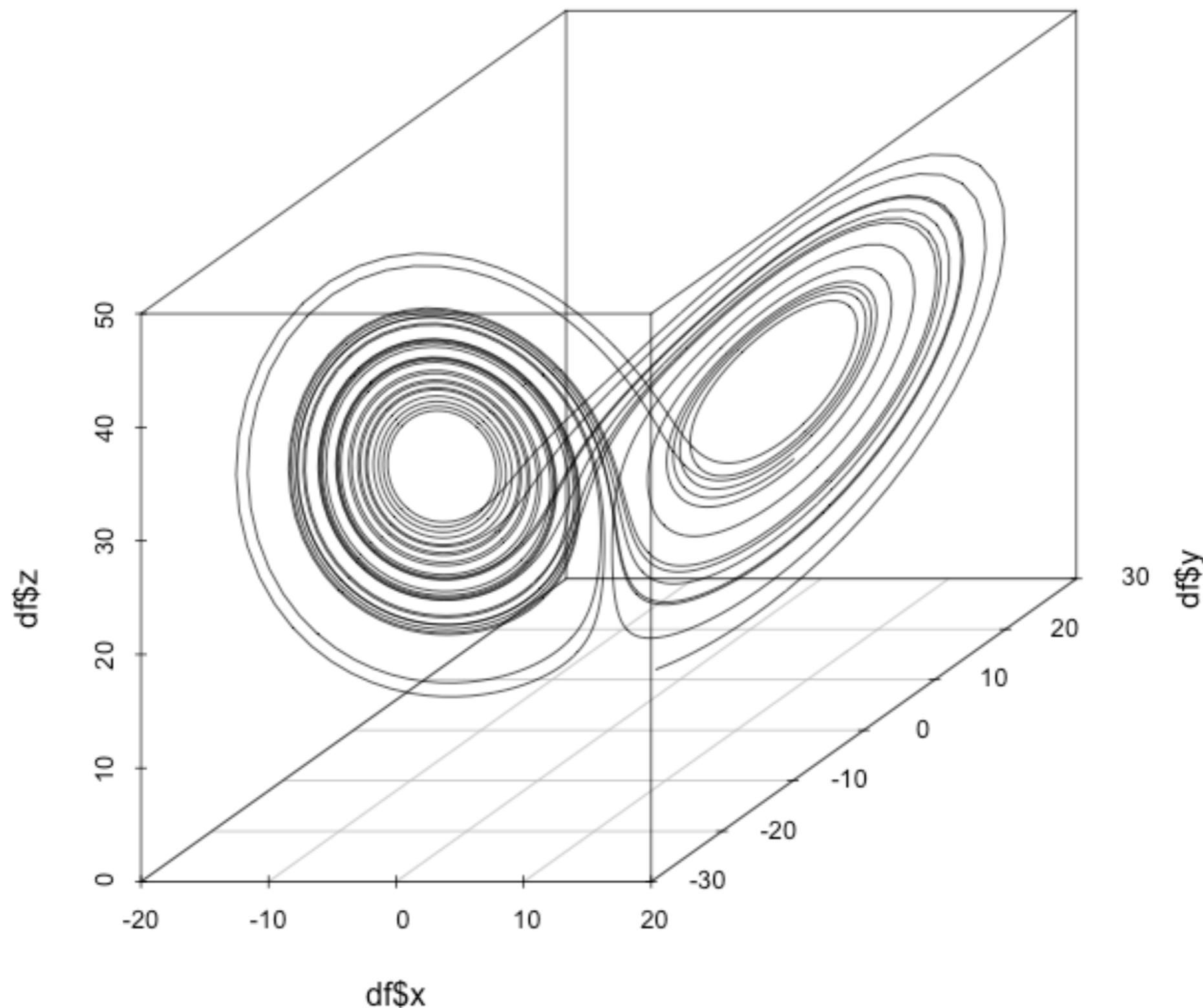
Procfile	initial commit	27 days ago
README.md	Update README.md	27 days ago
manifest.yml	initial commit	27 days ago
requirements.txt	initial commit	27 days ago
simu.py	nice ui, data url	24 days ago

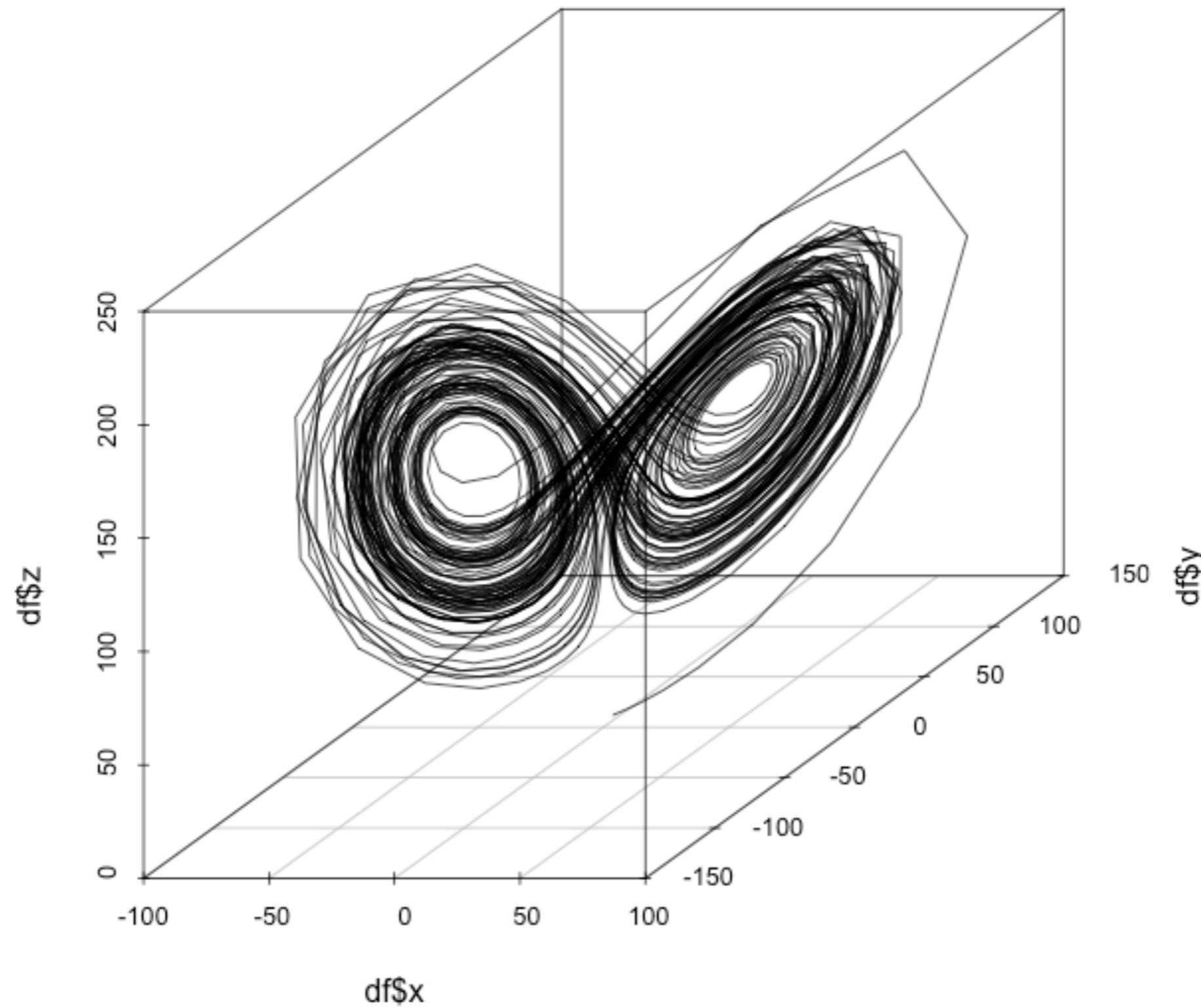
README.md

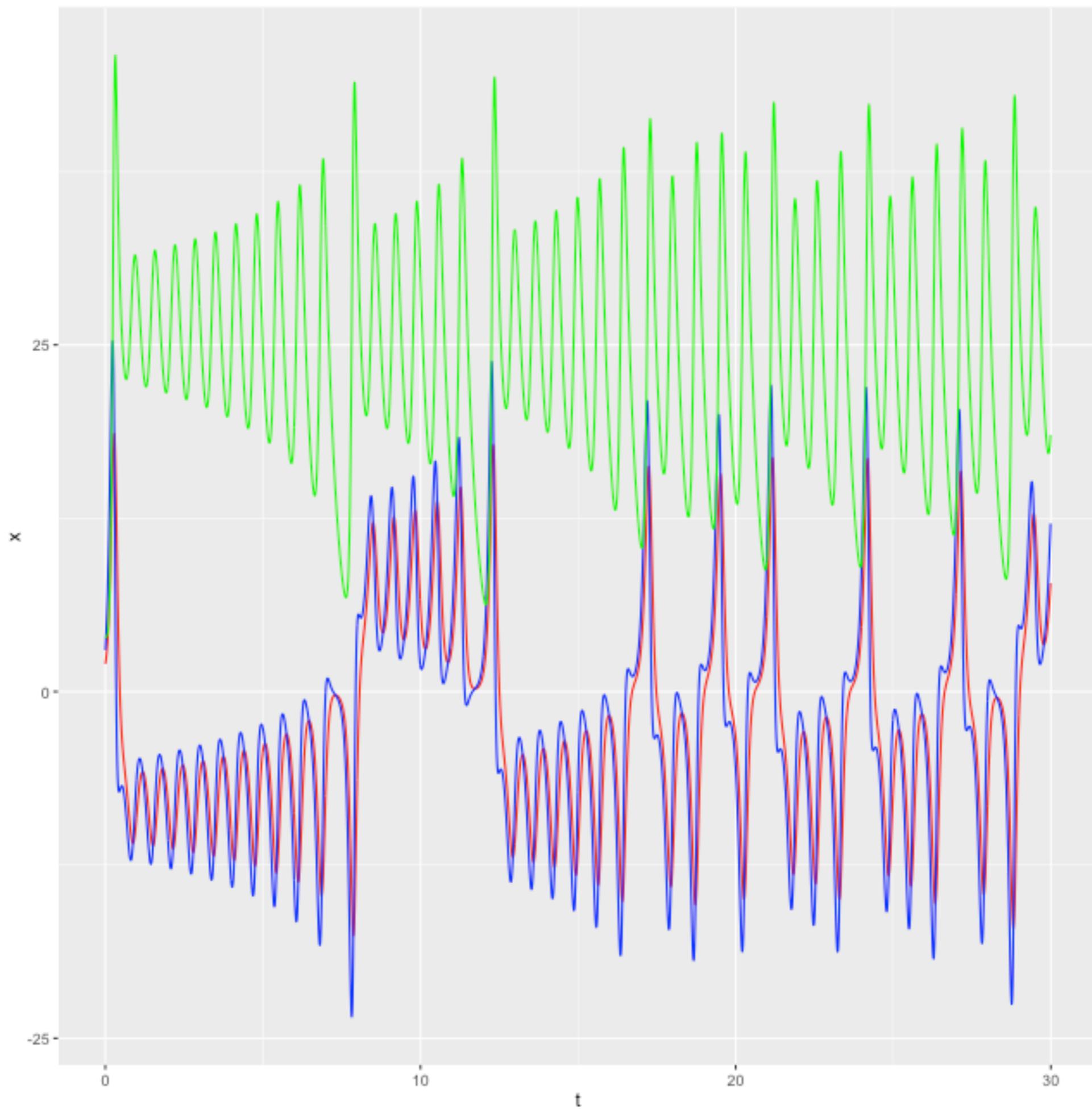
**pmqsimulator**

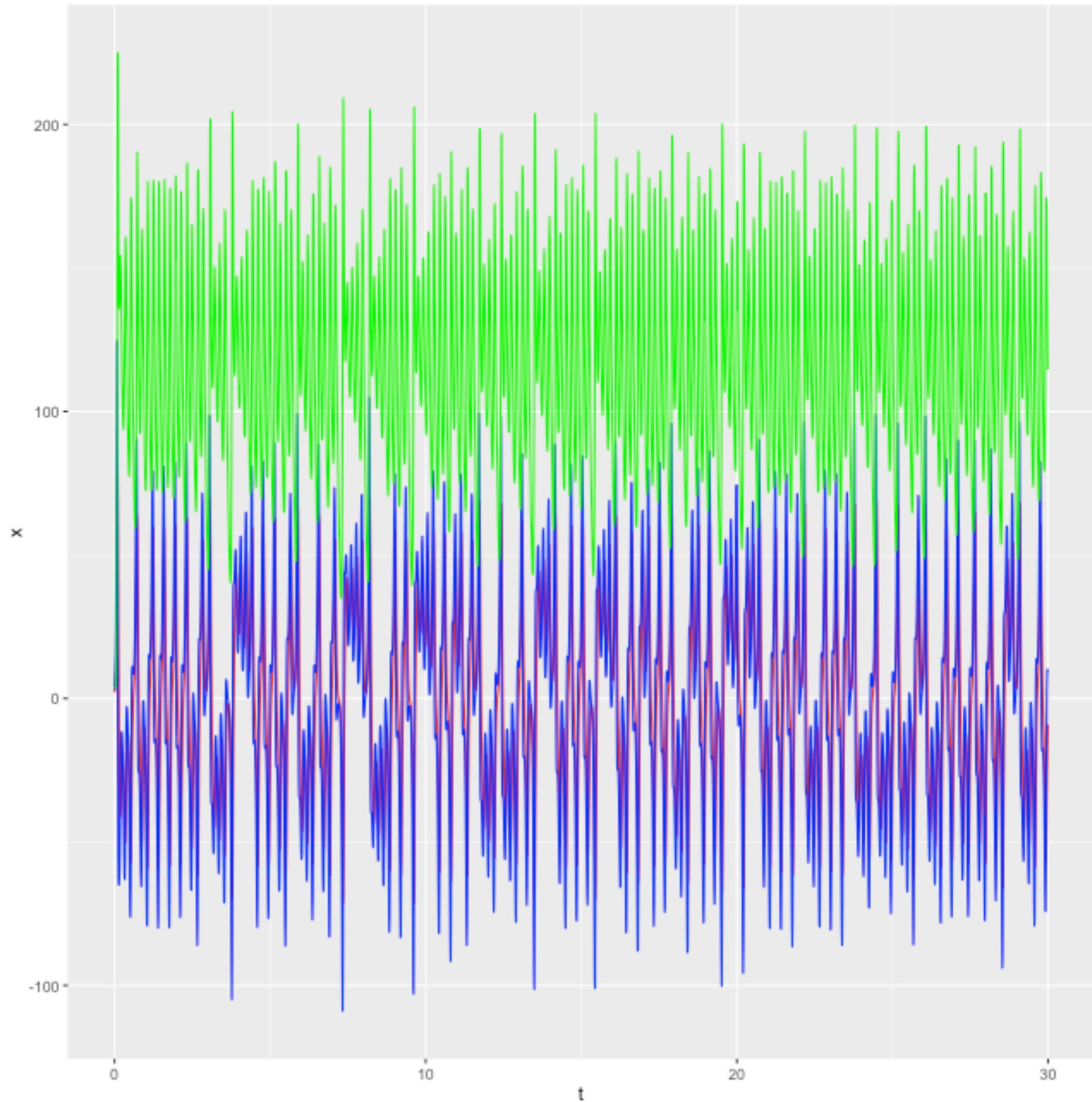
 Deploy to Bluemix

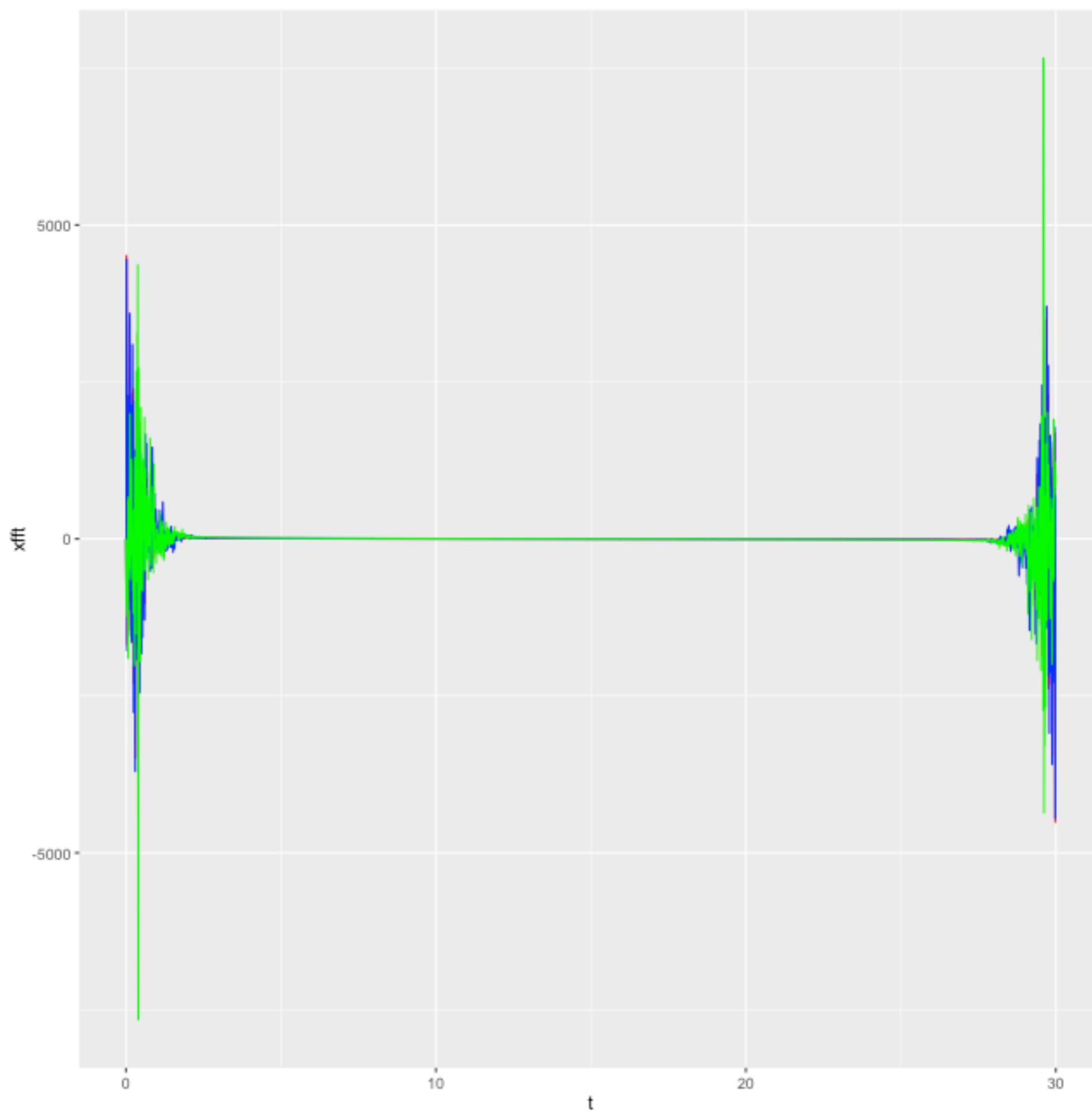
<https://github.com/romeokienzler/pmqsimulator>  
<https://ibm.biz/joinIBMCloud>

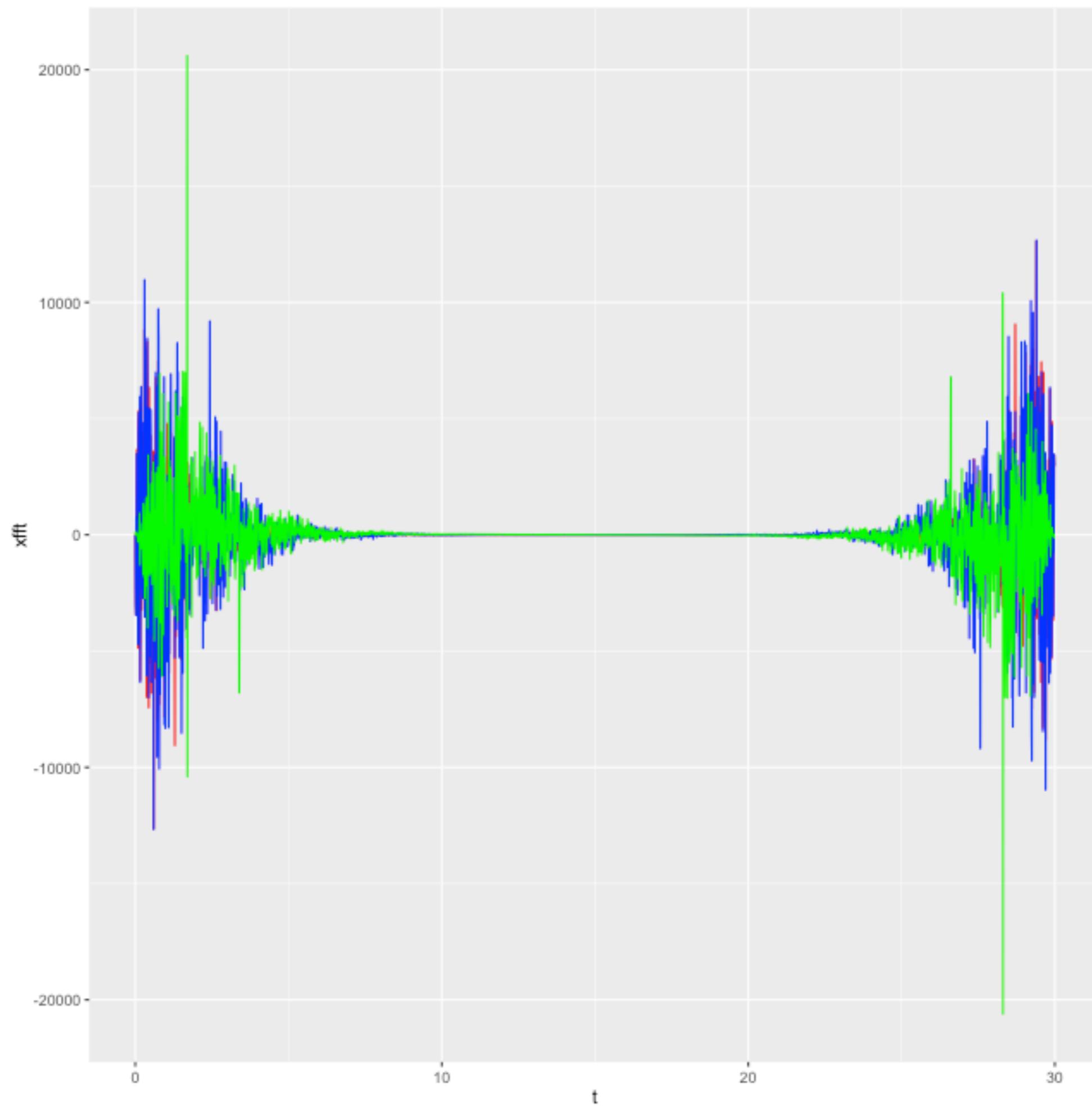












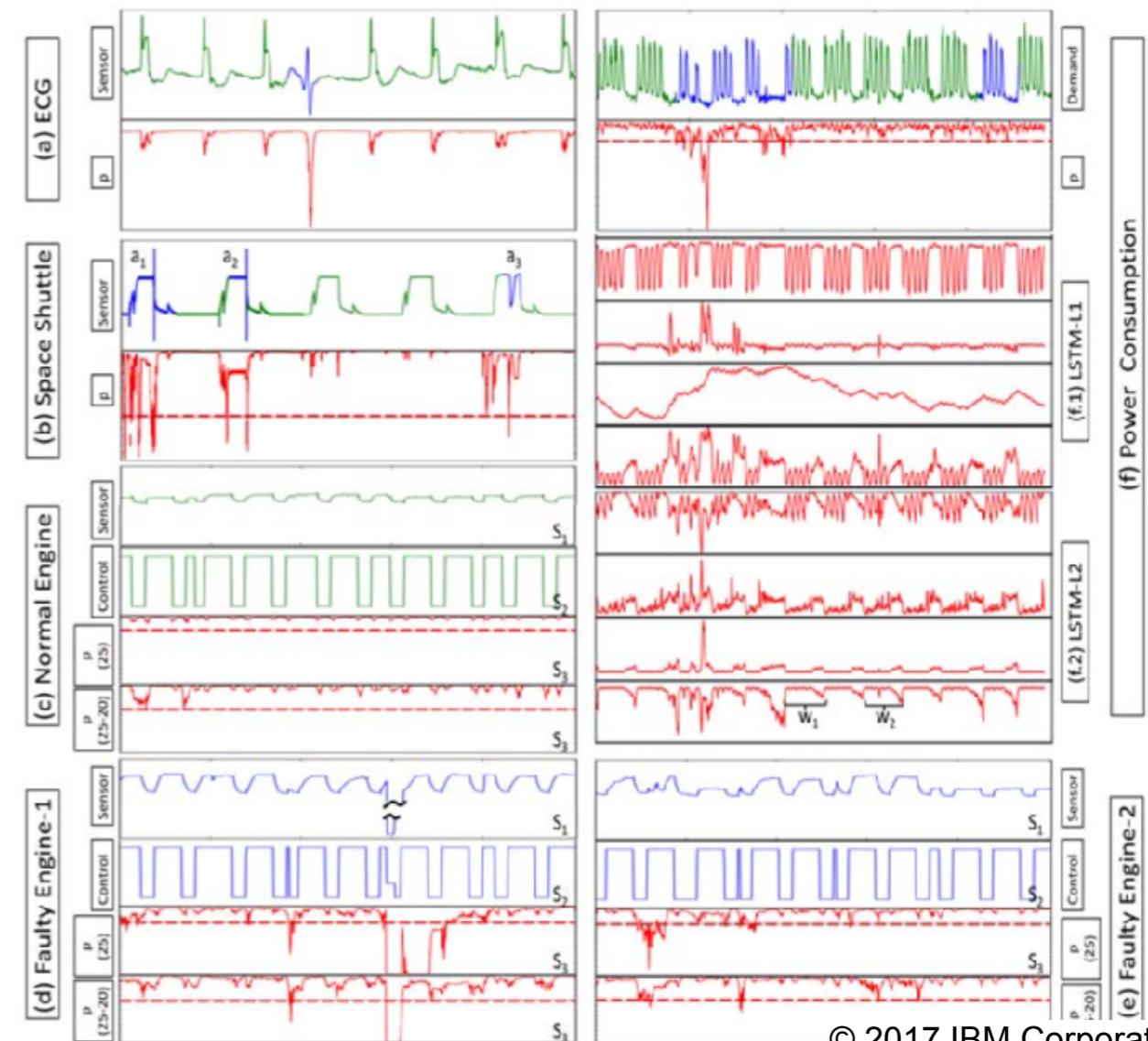
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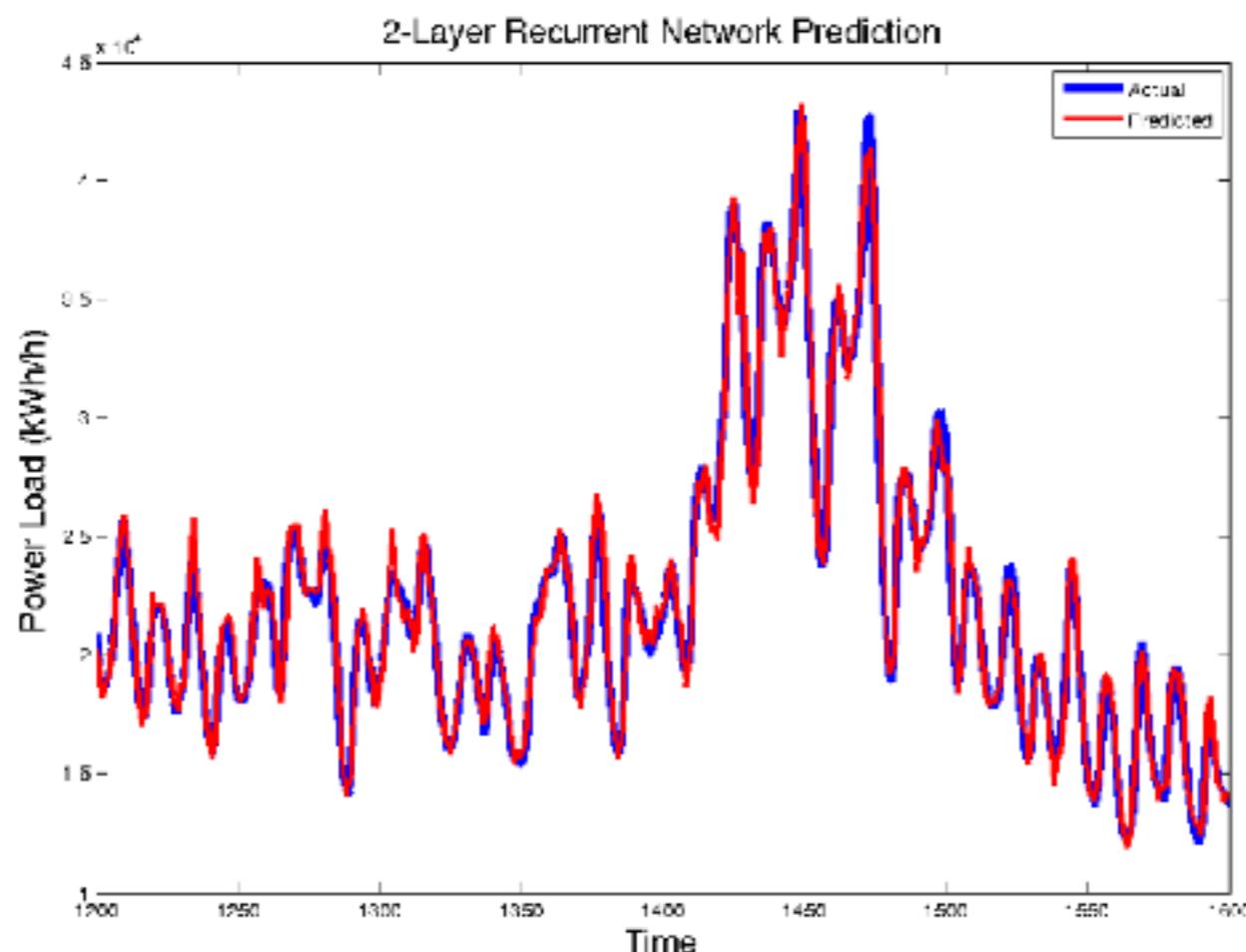
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## Deep Autoencoder

