Harvard

Yá’át’ééh 👋

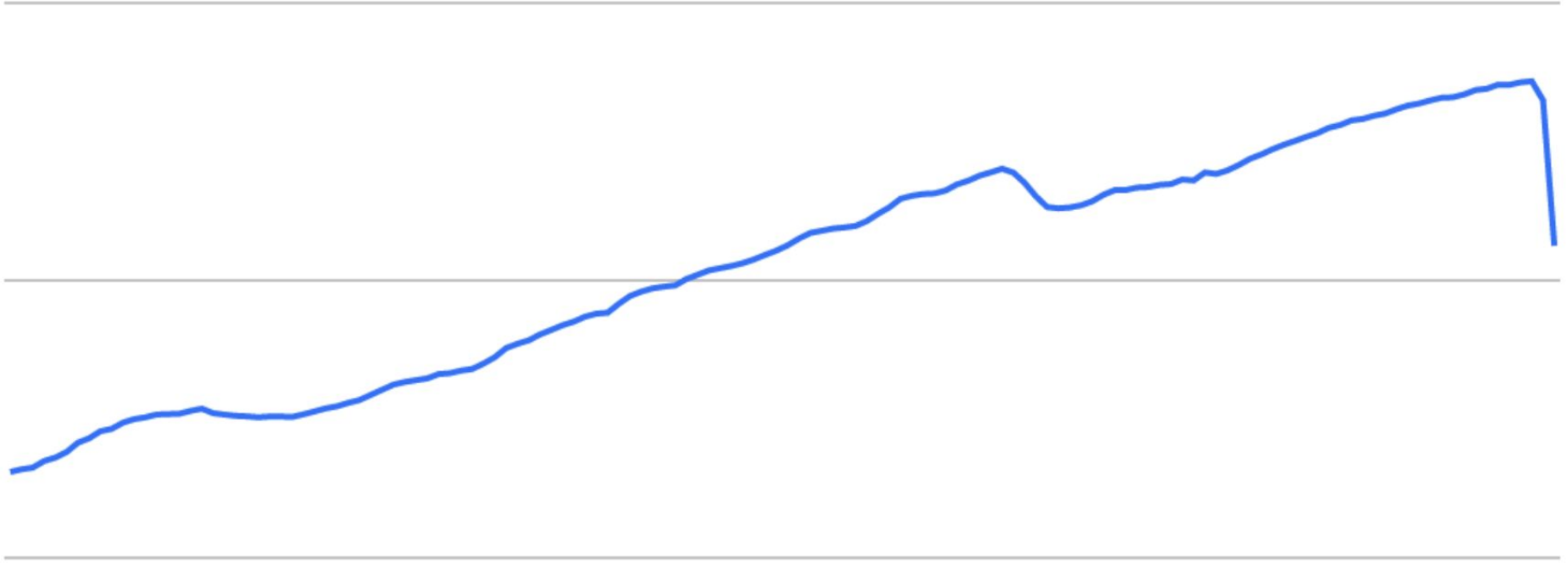
CRESTLEX 3.0

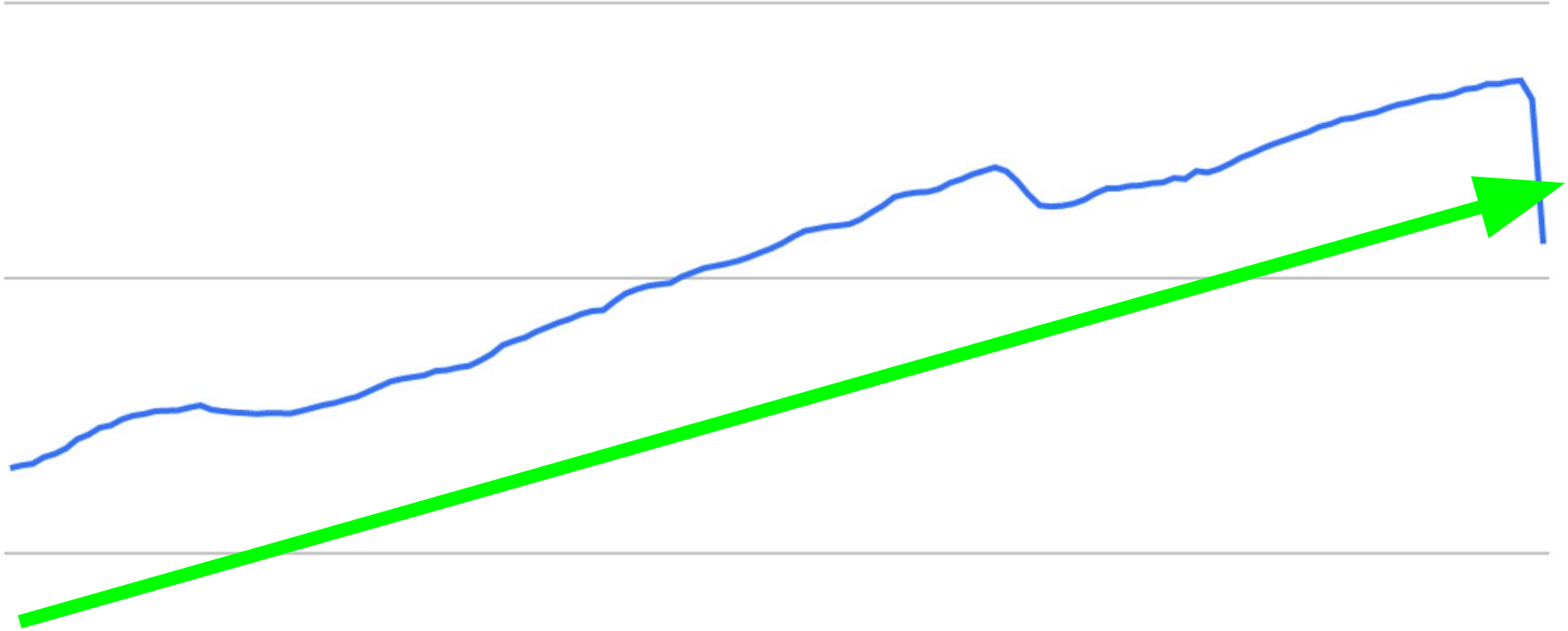
CReating **E**ffective **ST**em
Learning **EX**periences

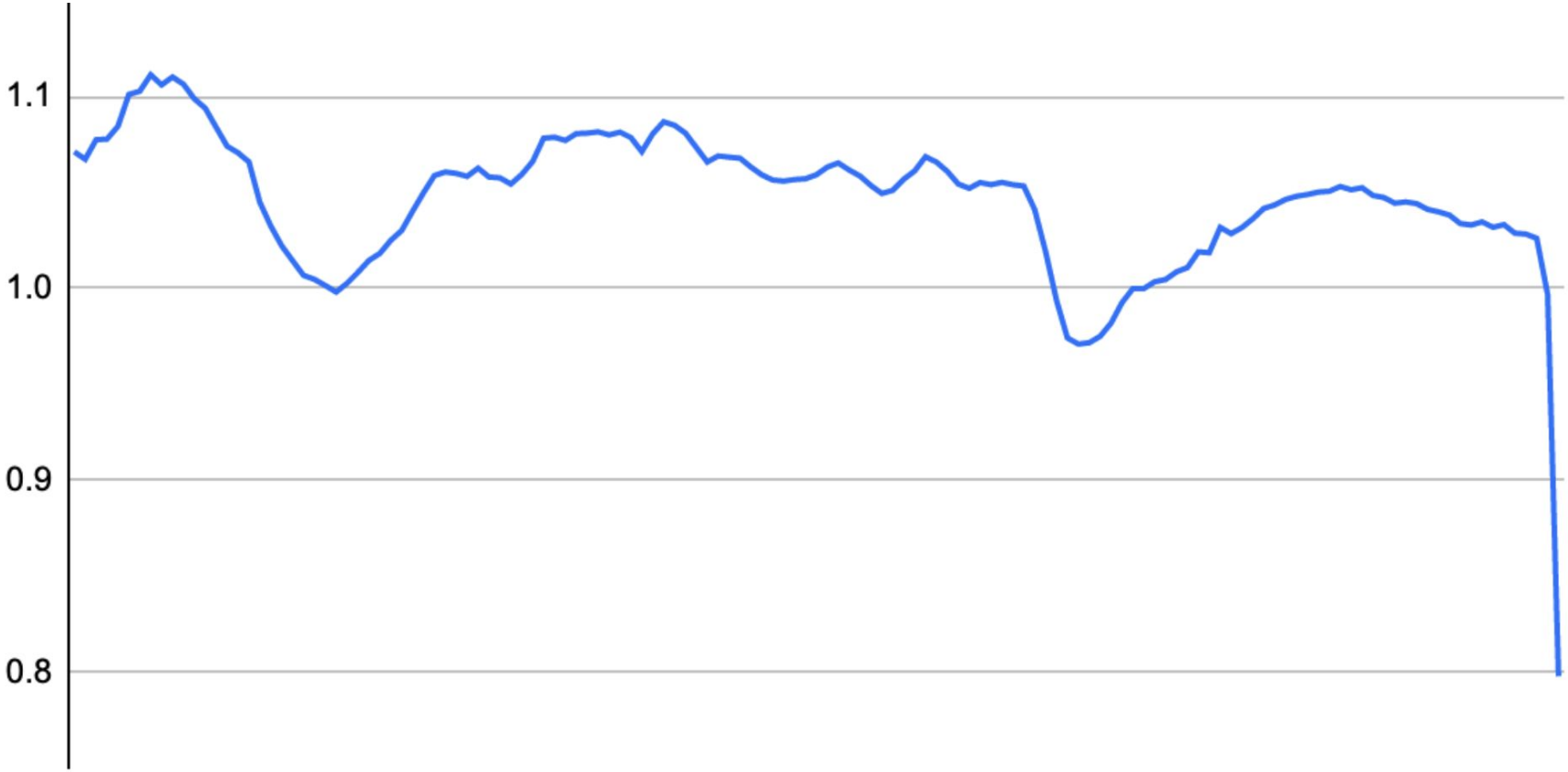
with Navajo Tech

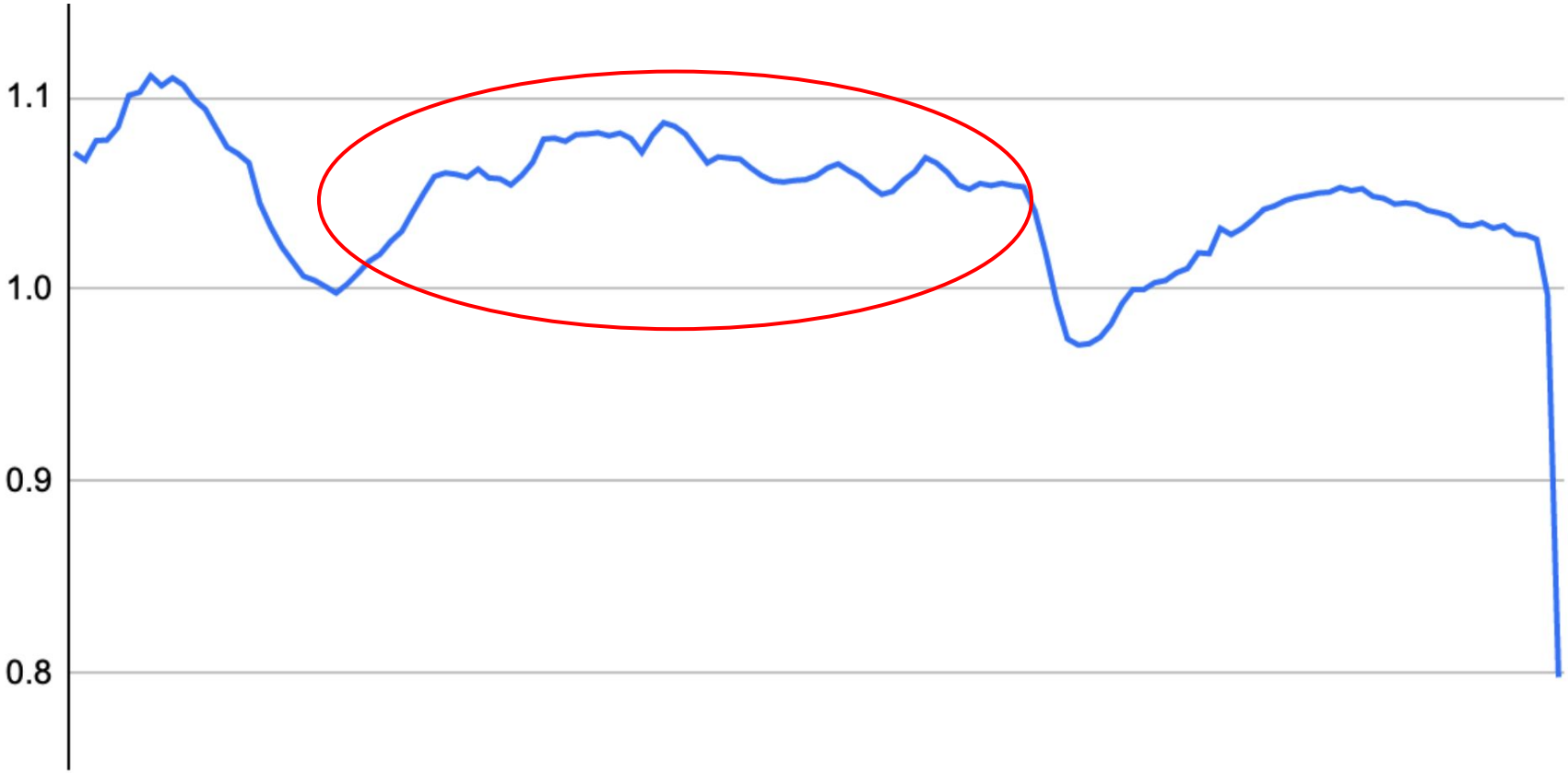
AI and ML for today and tomorrow...

Laurence Moroney
@lmoroney






1.1
1.0
0.9
0.8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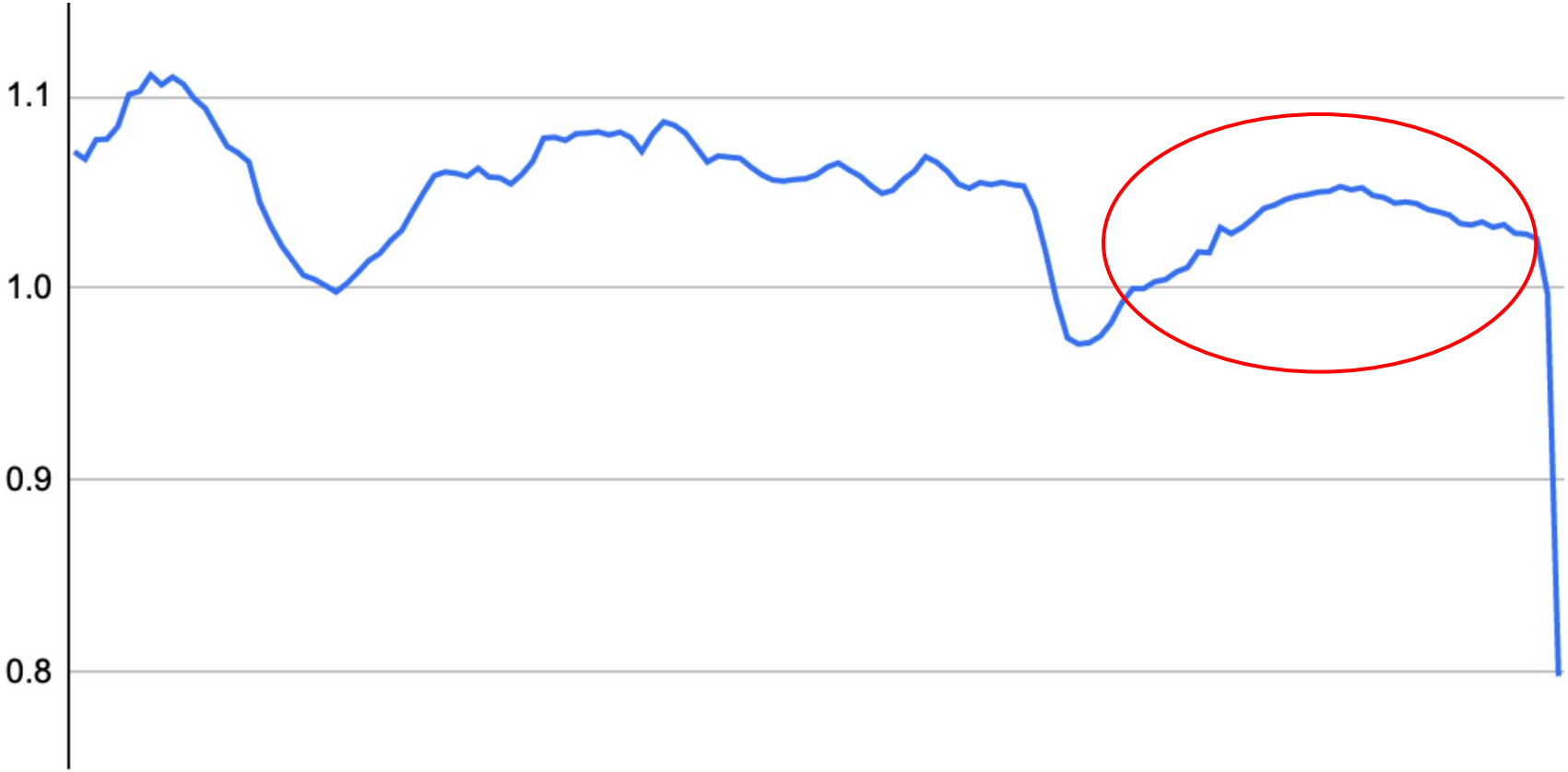

1.1
1.0
0.9
0.8

World Economic Forum - Jobs of Tomorrow Report

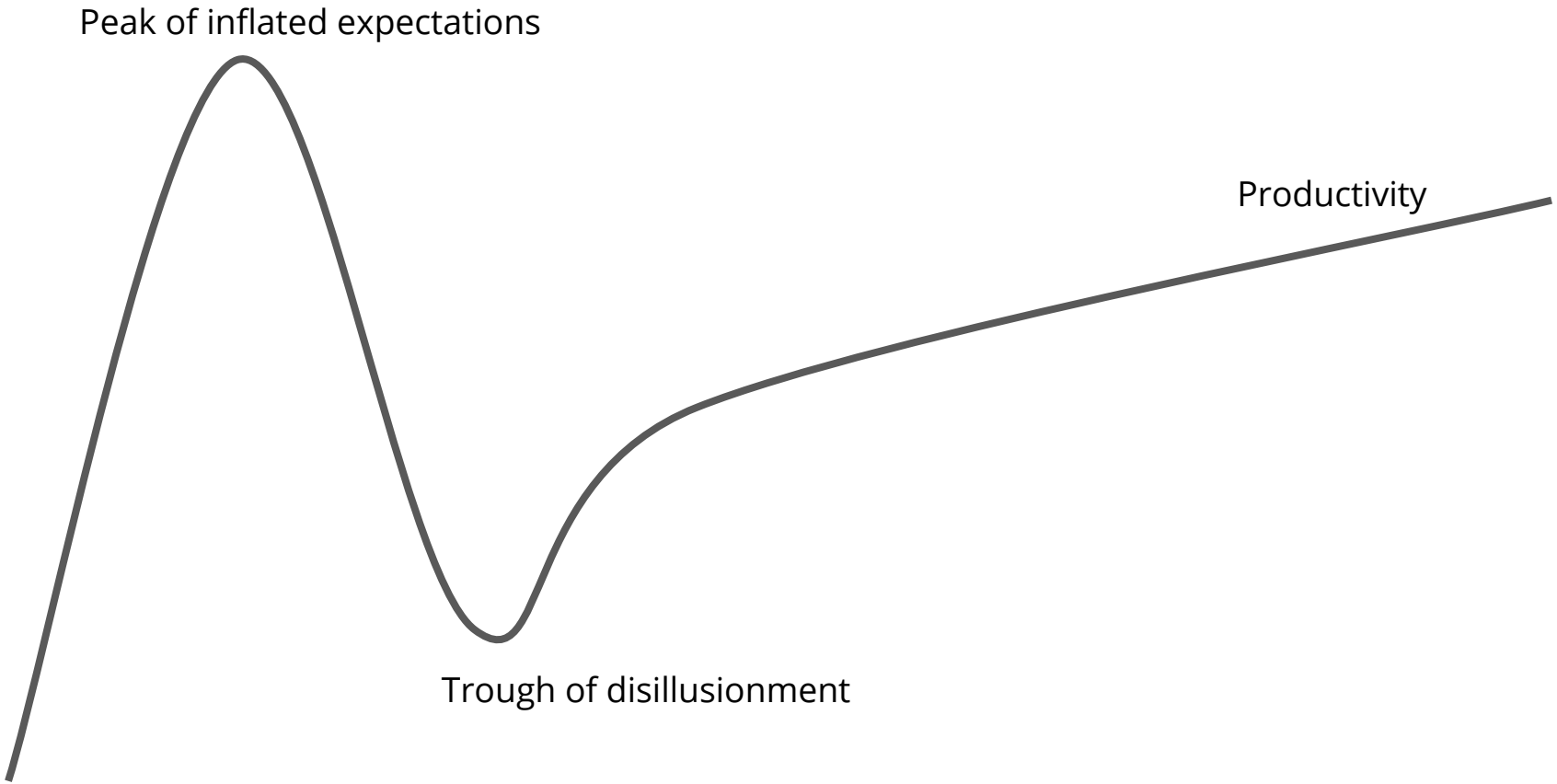
http://www3.weforum.org/docs/WEF_Jobs_of_Tomorrow_2020.pdf

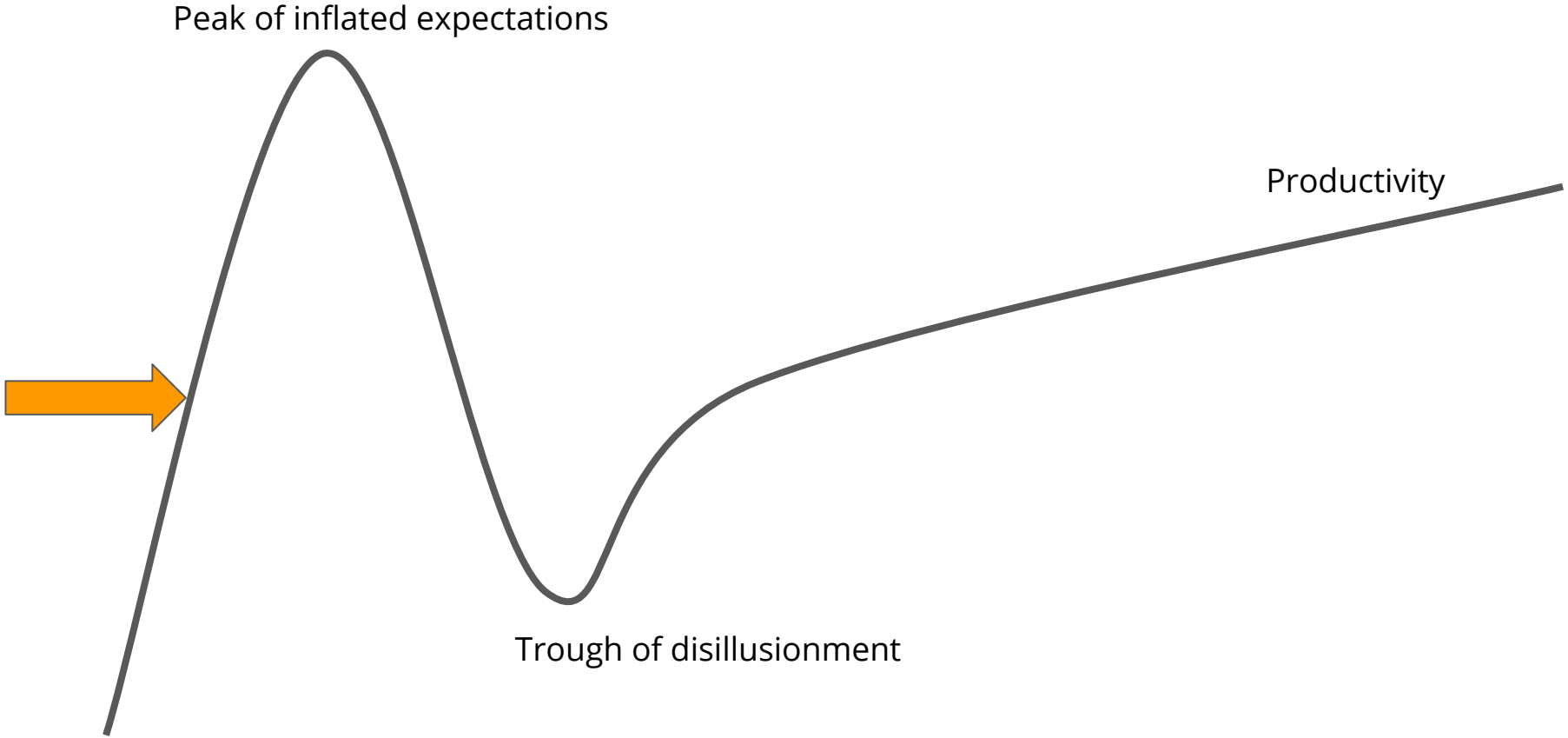
- Data and AI +37%
- Engineering and Cloud Computing +34%
- People and Culture +18%
- Product Development +27%
- Sales and Marketing +30%

Forbes Report

https://bit.ly/3dOUiws

- Global ML Market: $1.58B in 2017 -> $20.83B by 2024
  - CAGR of 44.06%
- AI Software Revenue: $10.1B in 2018 -> $126B in 2025
  - CAGR of 43.41%
- LinkedIn:
  - 44,864 jobs in the USA /
  - 98,371 globally


Peak of inflated expectations
Productivity
Trough of disillusionment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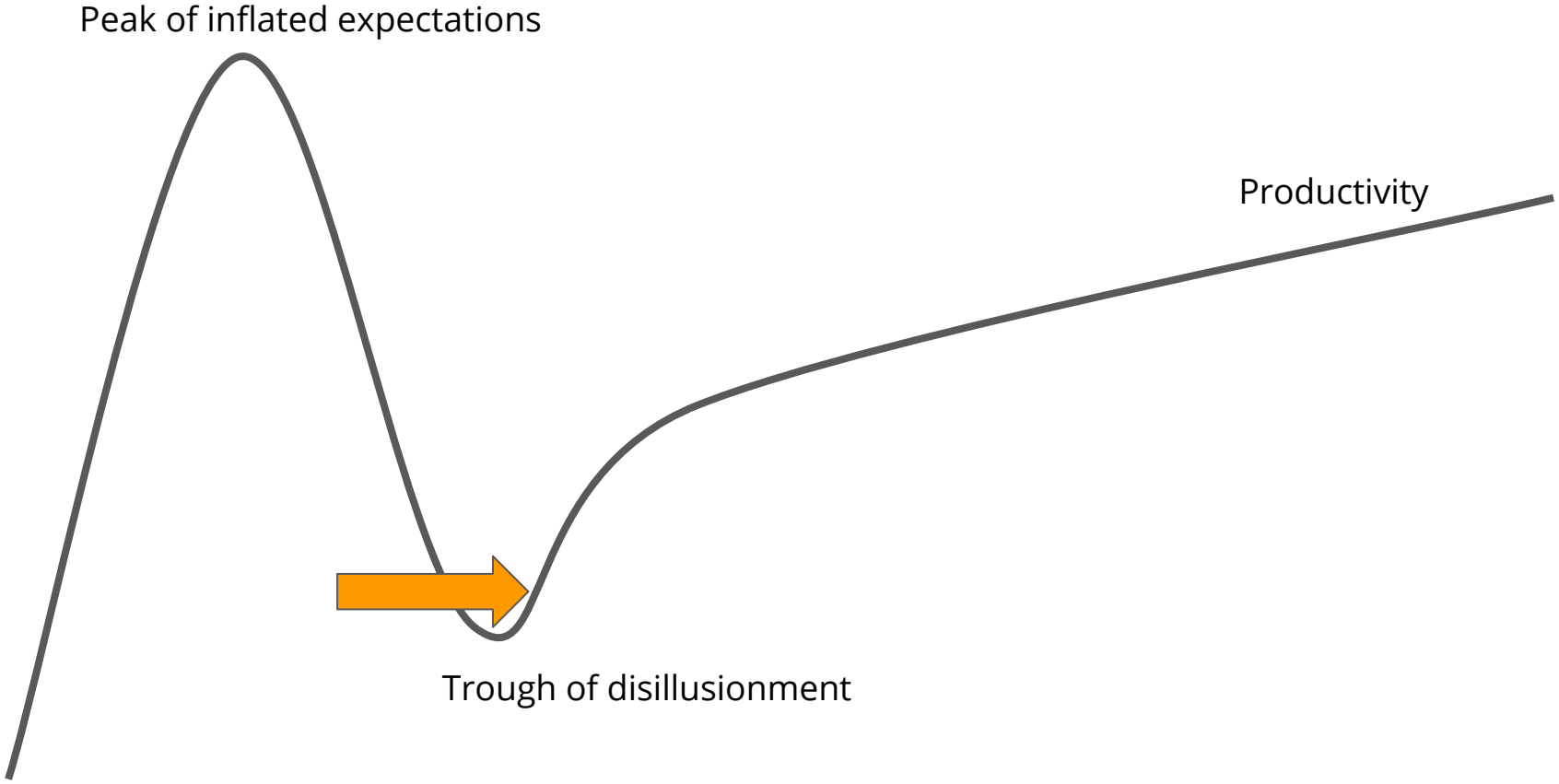
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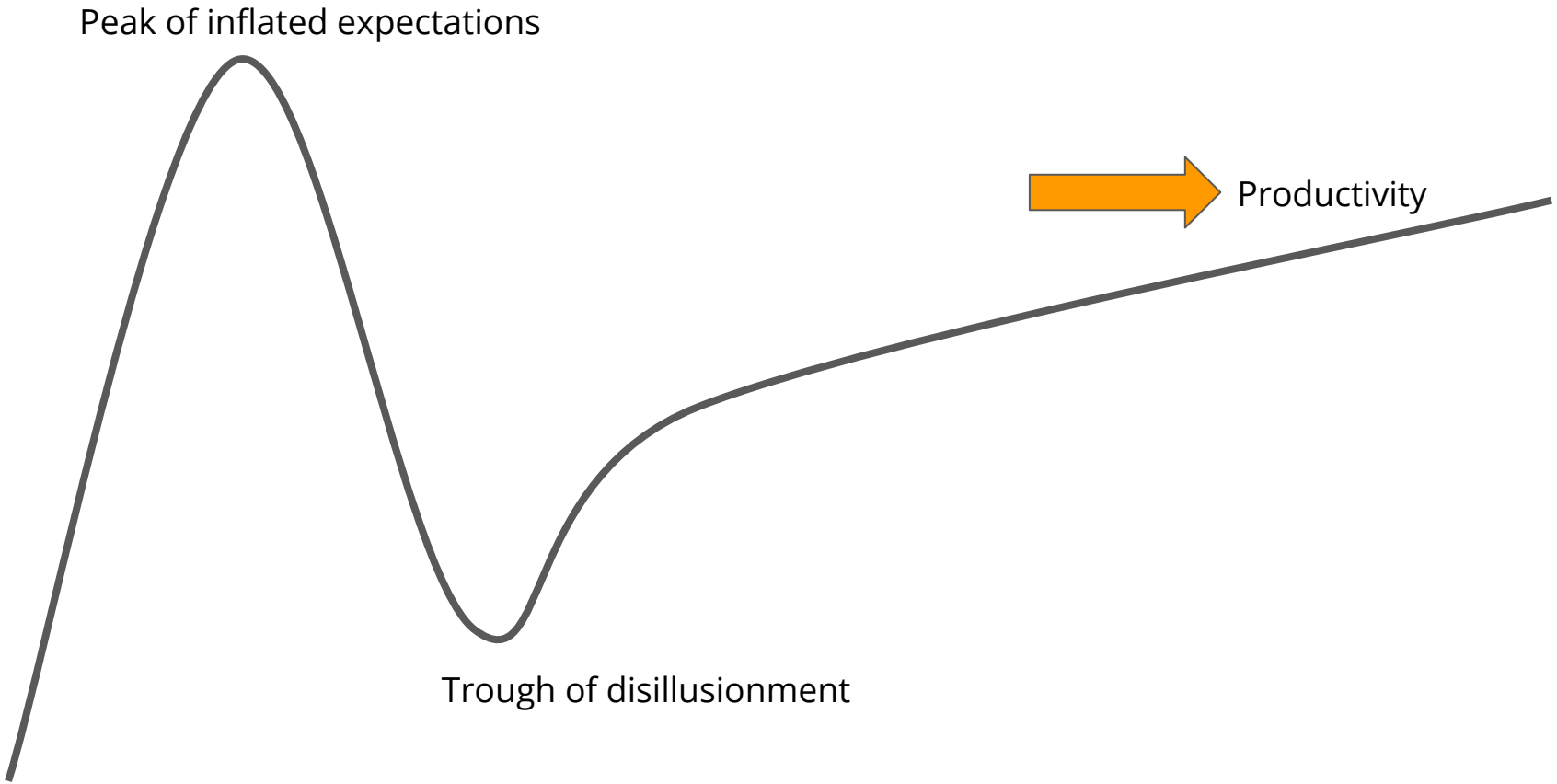
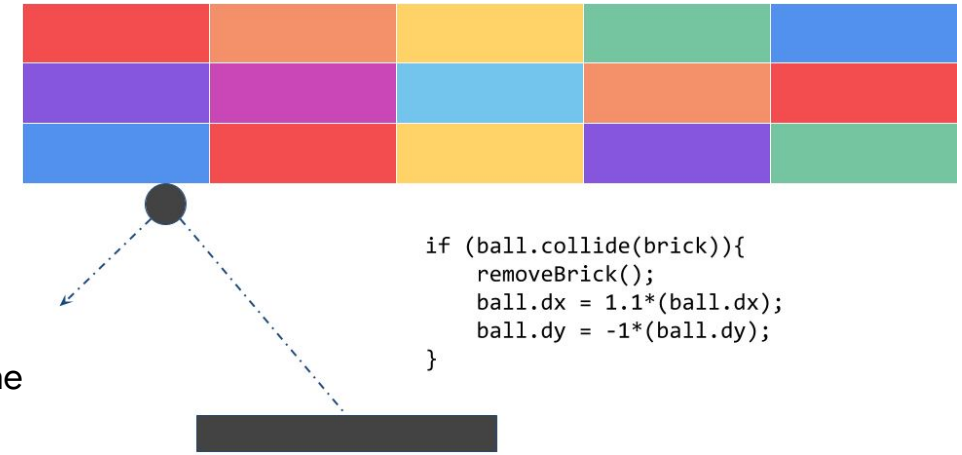

Peak of inflated expectations
Productivity
Trough of disillusionment

Explicit Coding



Defining rules that determine behavior of a program

Everything is pre-calculated and pre-determined by the programmer

Scenarios are limited by program complexity

The Traditional Programming Paradigm

Consider Activity Detection

```
if(speed<4){
    status=WALKING;
}
```

Consider Activity Detection

```
if(speed<4){
    status=WALKING;
}
```

```
if(speed<4){
    status=WALKING;
} else {
    status=RUNNING;
}
```

Consider Activity Detection

```
if(speed<4){
    status=WALKING;
}
```

```
if(speed<4){
    status=WALKING;
} else {
    status=RUNNING;
}
```

```
if(speed<4){
    status=WALKING;
} else if(speed<12){
    status=RUNNING;
} else {
    status=BIKING;
}
```

Consider Activity Detection

```
if(speed<4){
    status=WALKING;
}
```

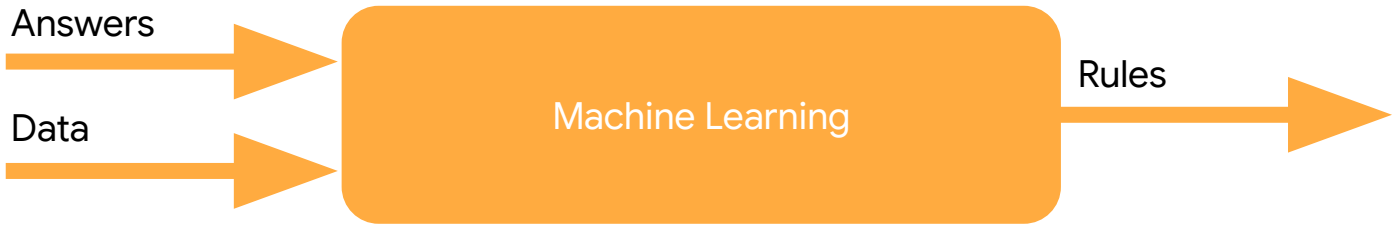
```
if(speed<4){
    status=WALKING;
} else {
    status=RUNNING;
}
```

```
if(speed<4){
    status=WALKING;
} else if(speed<12){
    status=RUNNING;
} else {
    status=BIKING;
}
```

```
// ???
```

The Traditional Programming Paradigm

The Machine Learning Paradigm



Activity Detection with Machine Learning

```
0101001010100101010
1001010101001011101
0100101010010101001
0101001010100101010
```

Label = WALKING

```
1010100101001010101
0101010010010010001
0010011111010101111
1010100100111101011
```

Label = RUNNING

```
1001010011111010101
1101010111010101110
1010101111010101011
1111110001111010101
```

Label = BIKING

```
1111111111010011101
0011111010111110101
0101110101010101110
1010101010100111110
```

Label = GOLFING

The Machine Learning Paradigm

```
01010010101100101010
10010101010010111101
01001010100101011001
01010010101001010010
```

Label = WALKING

```
10101001010010101010
01010100100100100001
00100111110101011111
10101001001111010011
```

Label = RUNNING

```
10010100111110101010
11010101110101011110
10101011110101010011
11111110001111010101
```

Label = BIKING

```
11111111110100111010
00111111010111110101
01011101010101011110
10101010100111110
```

Label = GOLFING

The Machine Learning Paradigm

```
0101001010100101010
1001010101001011101
0100101010010101001
0101001010100101010
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Label = WALKING

```
1010100101001010101
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1010100100111101011
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```
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1101010111010101110
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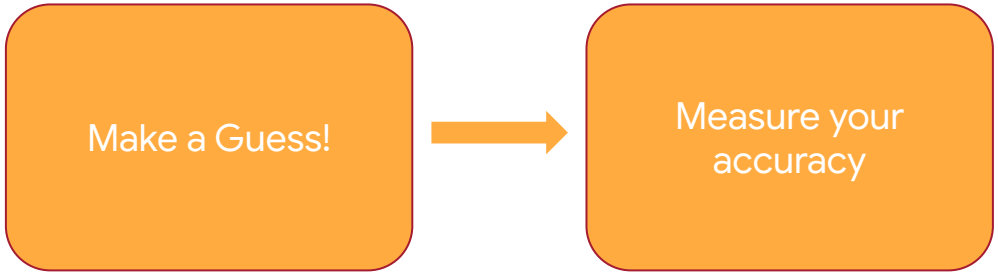
Label = GOLFING

The Machine Learning Paradigm

The Machine Learning Paradigm



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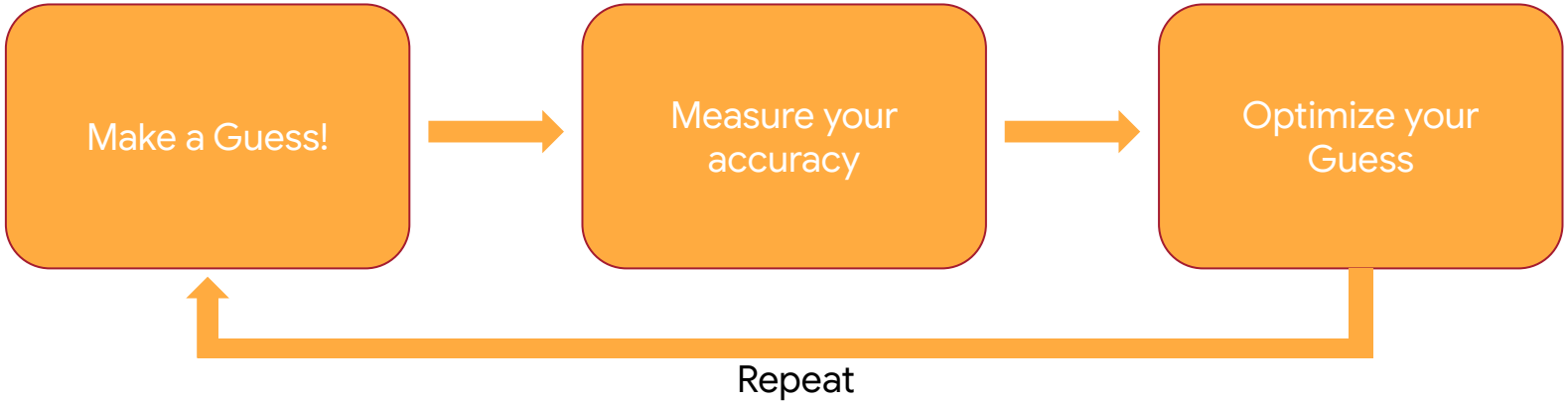

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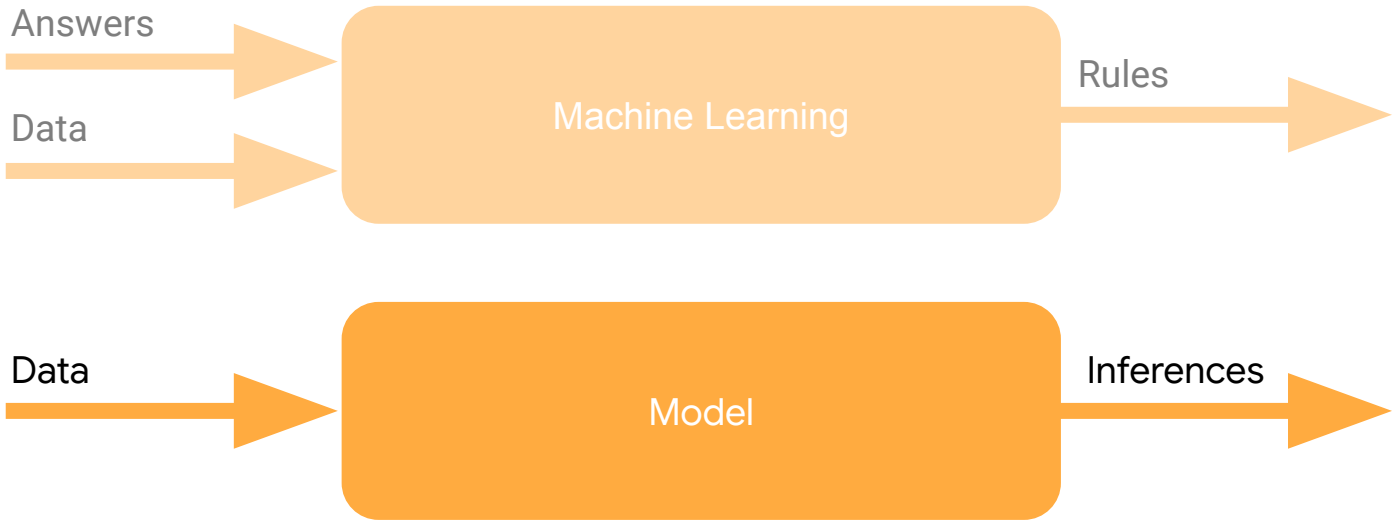

X = -1, 0, 1, 2, 3, 4

Y = -3, -1, 1, 3, 5, 7

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```

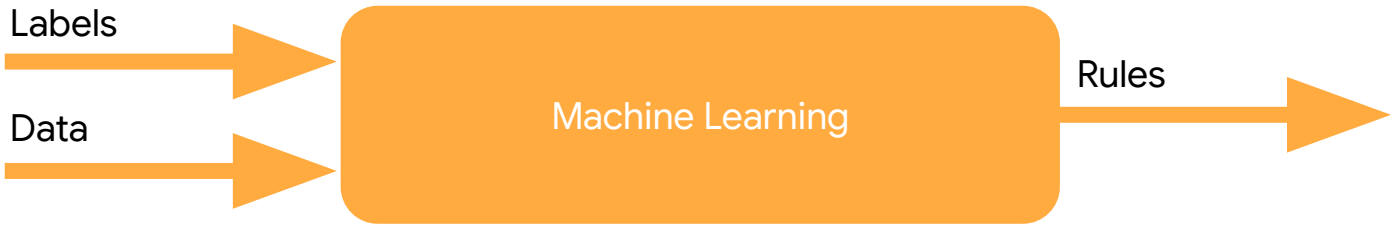

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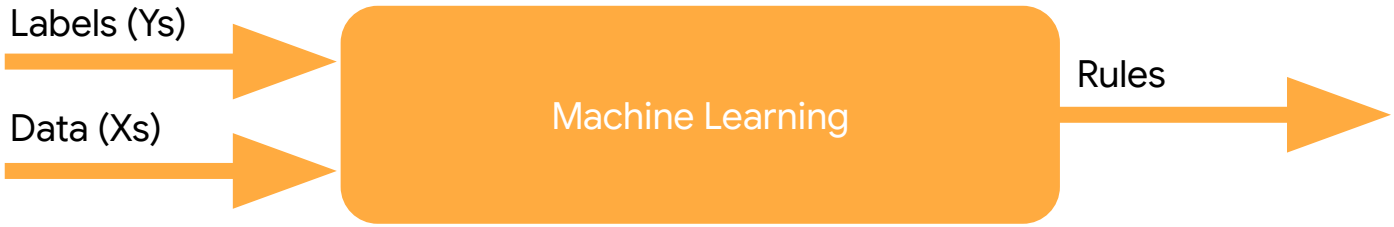

```
model = keras.Sequential([keras.layers.Dense(units=1, input_shape=[1])])
model.compile(optimizer='sgd', loss='mean_squared_error')

xs = np.array([-1.0, 0.0, 1.0, 2.0, 3.0, 4.0], dtype=float)
ys = np.array([-3.0, -1.0, 1.0, 3.0, 5.0, 7.0], dtype=float)

model.fit(xs, ys, epochs=500)

print(model.predict([10.0]))
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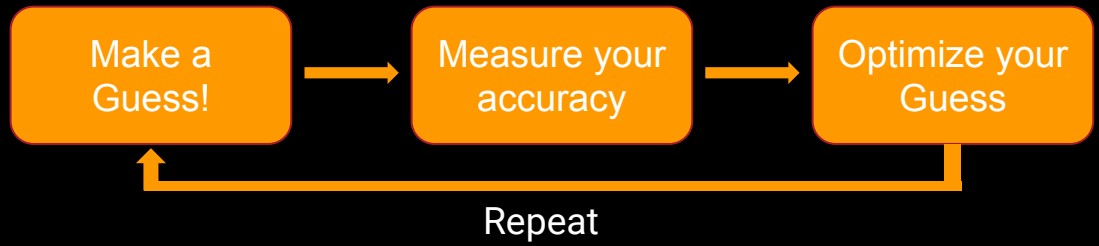

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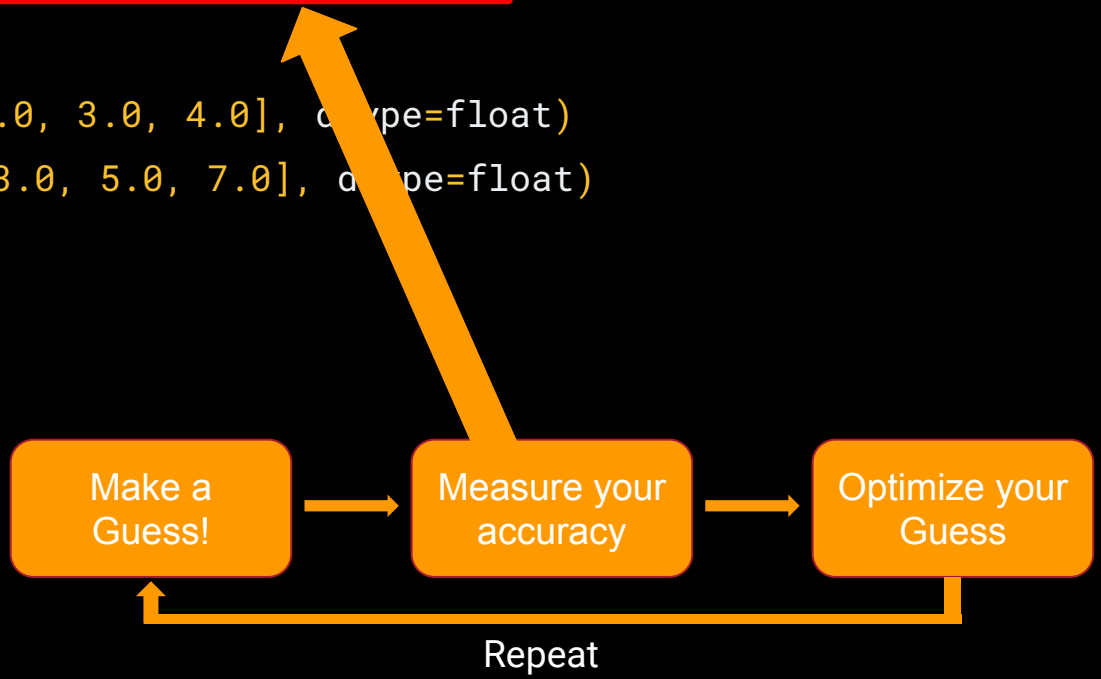

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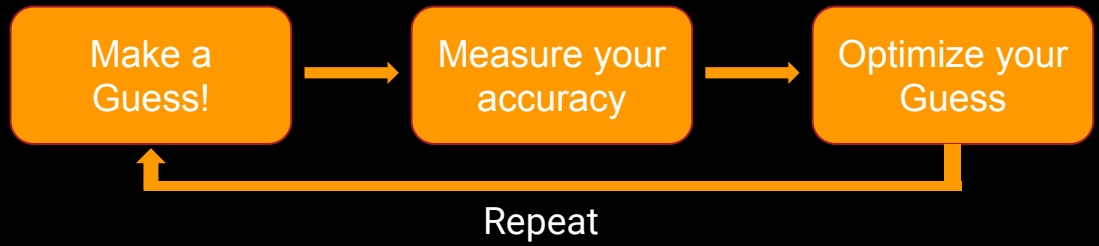

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```
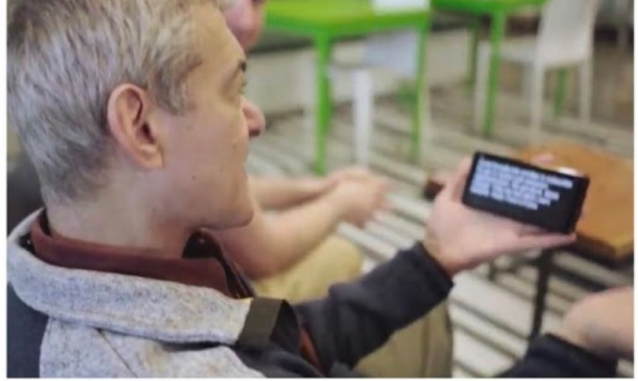


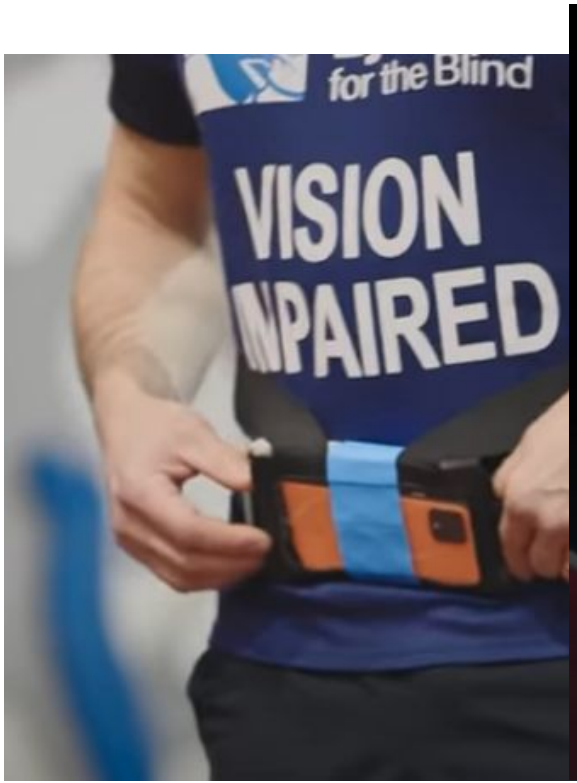
Likely lung
cancer detected
Initial scan with AI detection

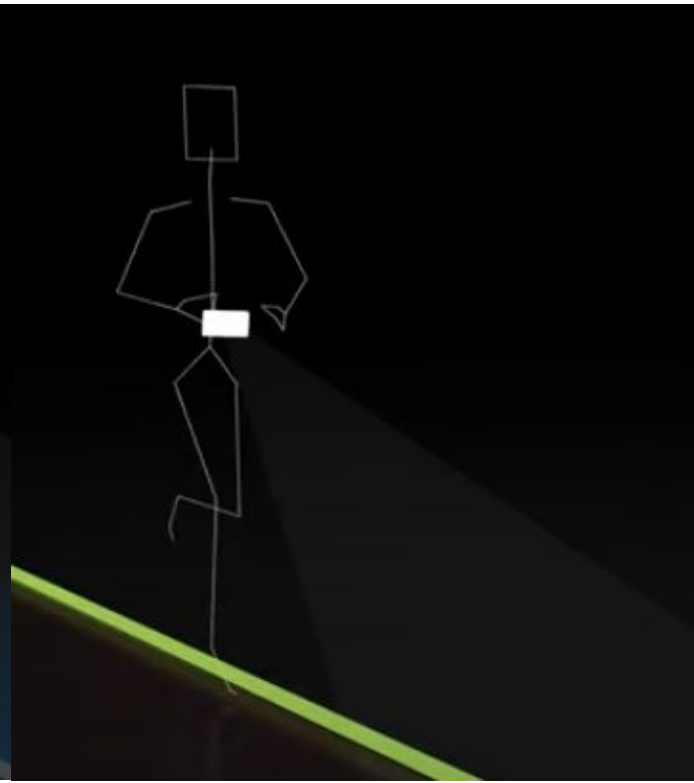


TensorFlow

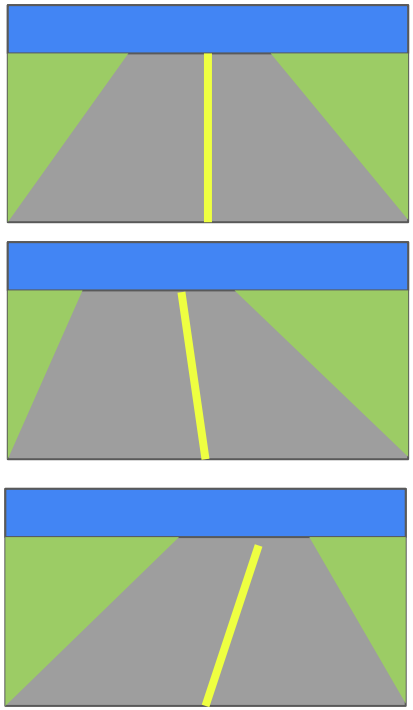

8-7=1
8-7=1
7+4=1
8-7=1
8-7=1

Project Guideline

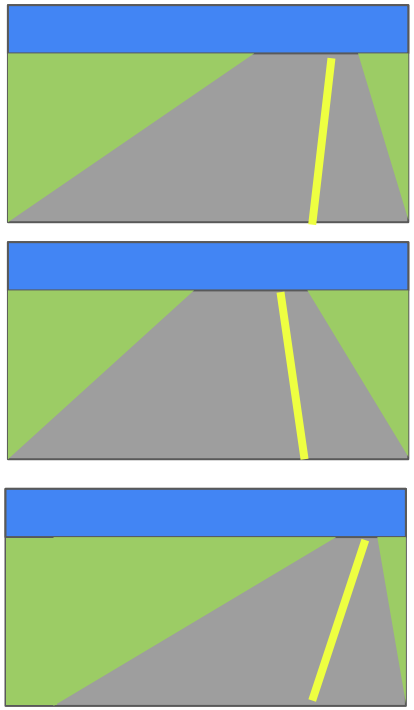




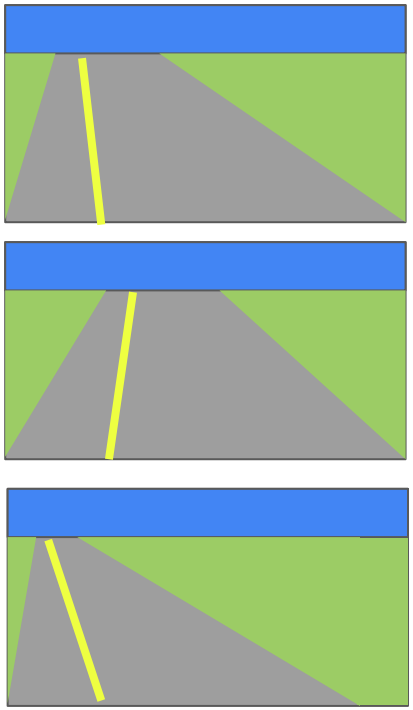
How would it work?



Good

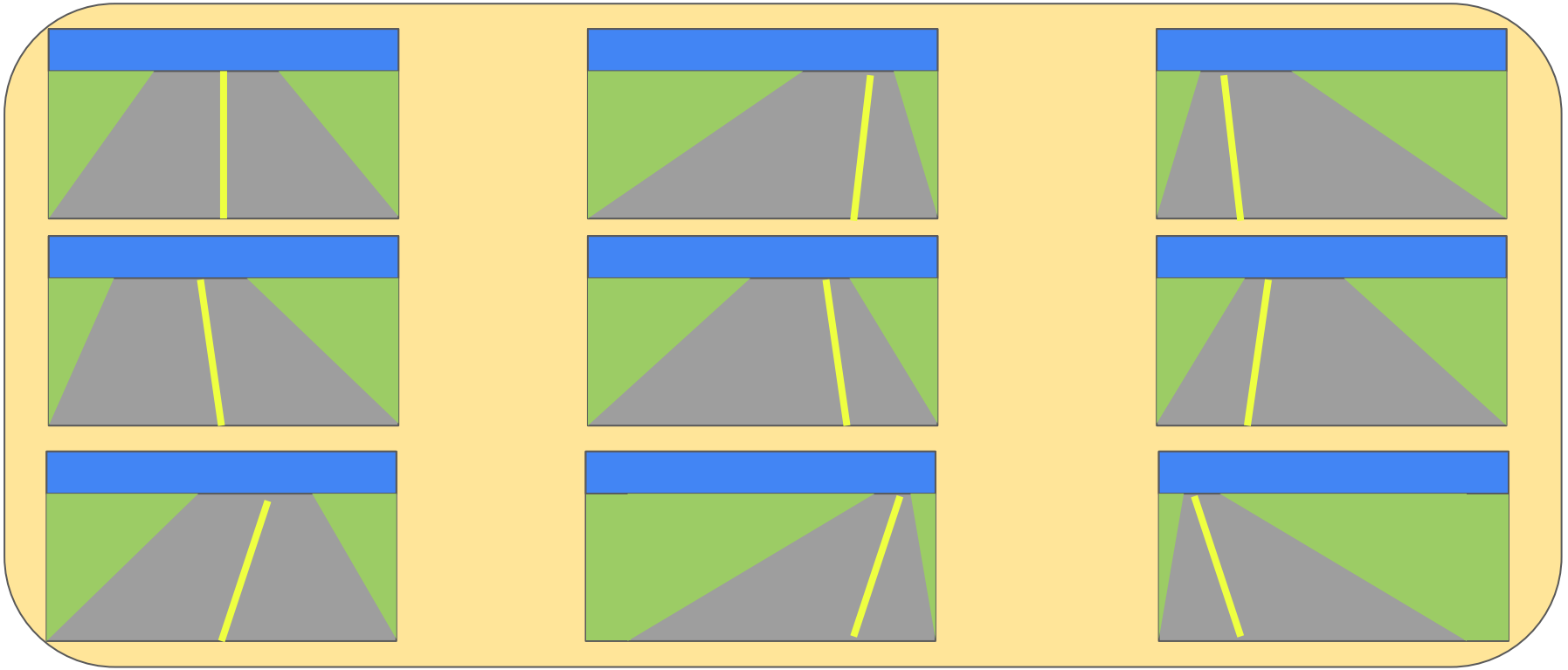


Move Right!



Move Left!

How would it work?



Good

Move Right!

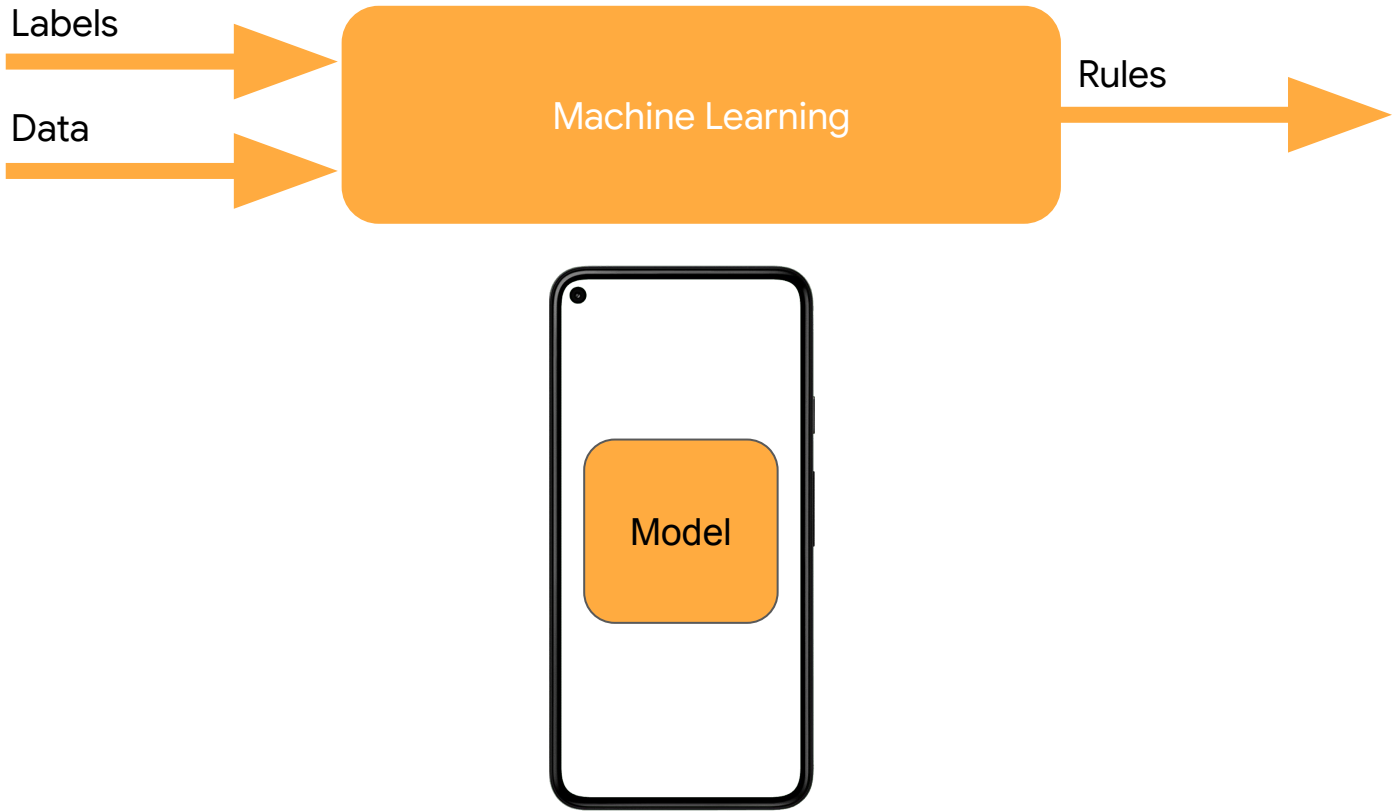
Move Left!

How would it work?

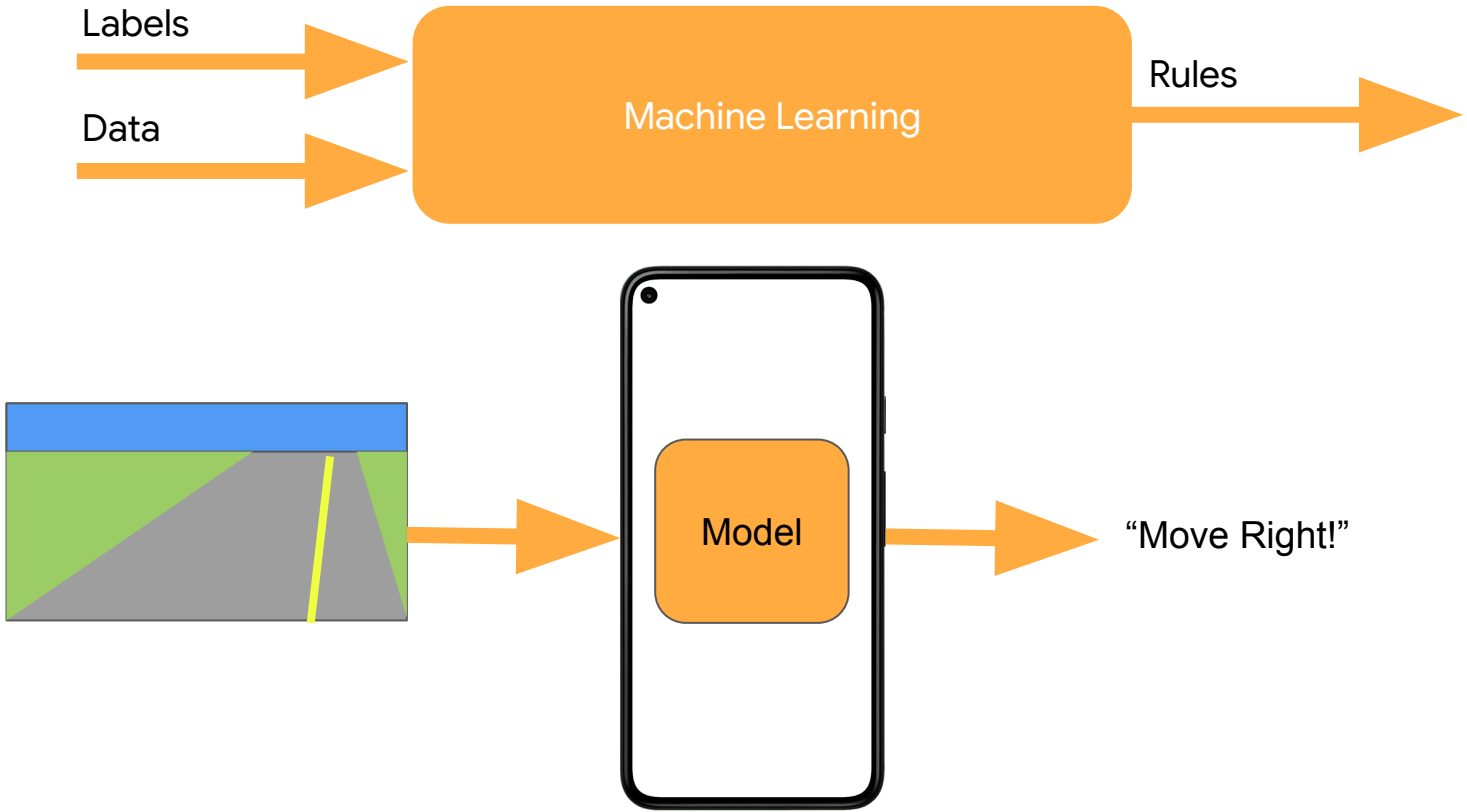
Good | Move Right! | Move Left!

The Machine Learning Paradigm

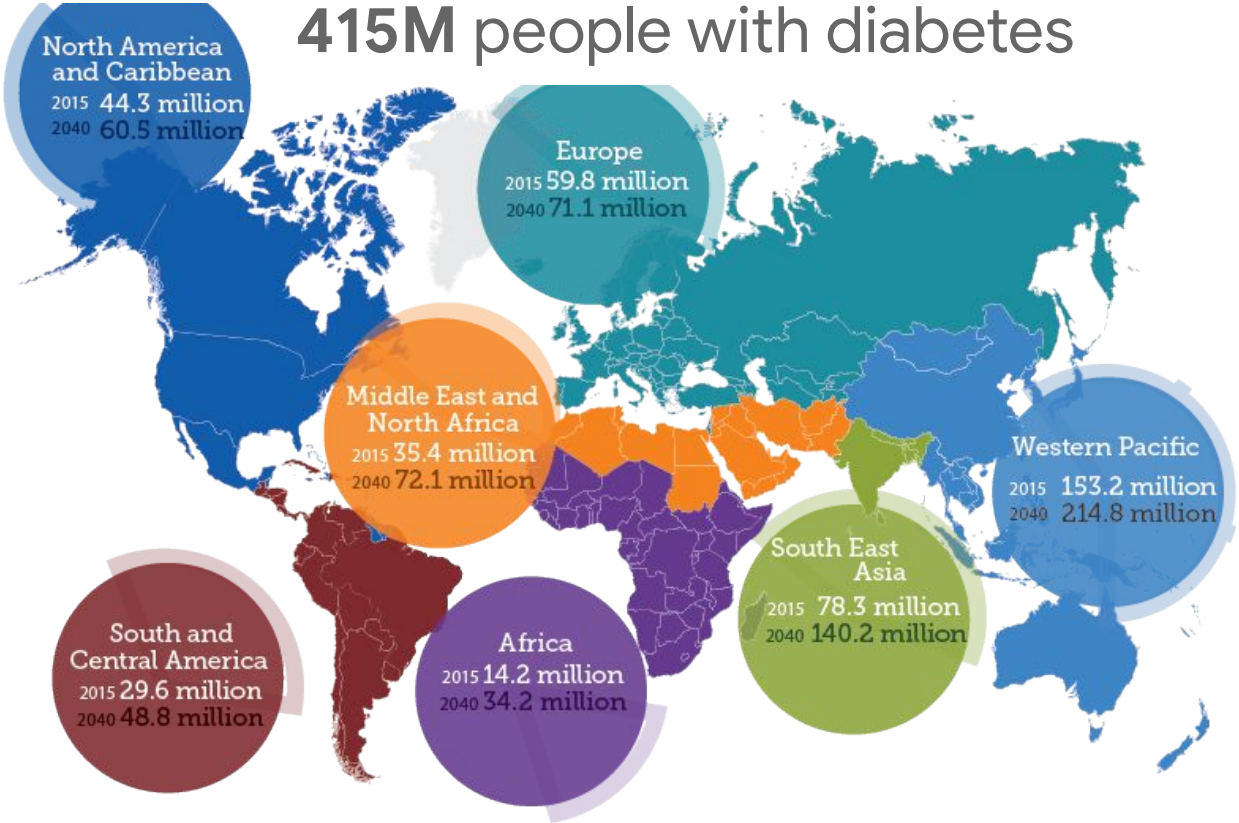
The Machine Learning Paradigm



The Machine Learning Paradigm



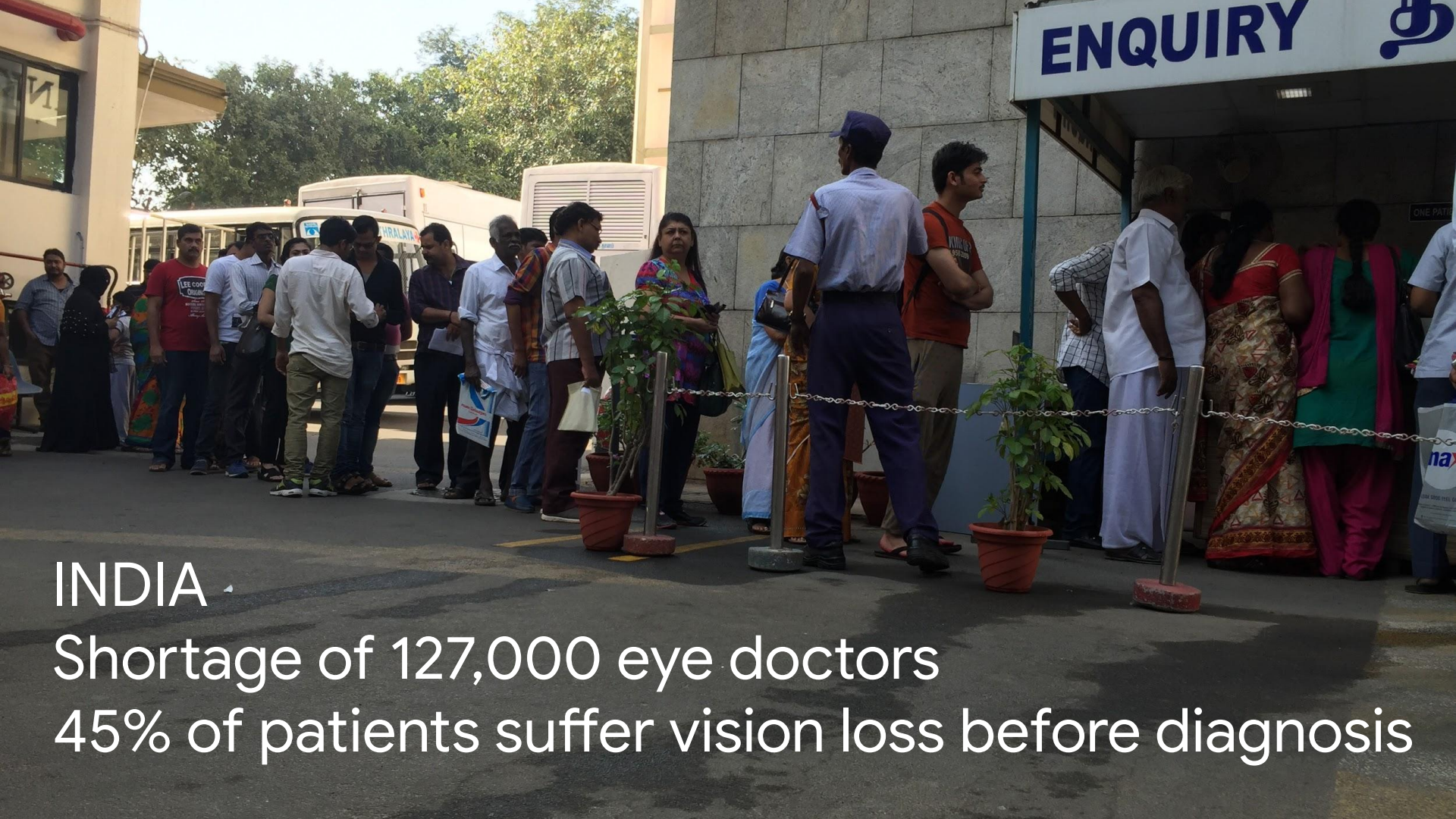
Diabetic retinopathy: fastest growing cause of blindness



Source: International Diabetes Federation 2015 Atlas, www.idf.org/e-library/epidemiology-research/diabetes-atlas/

Regular screening is key to preventing blindness

=



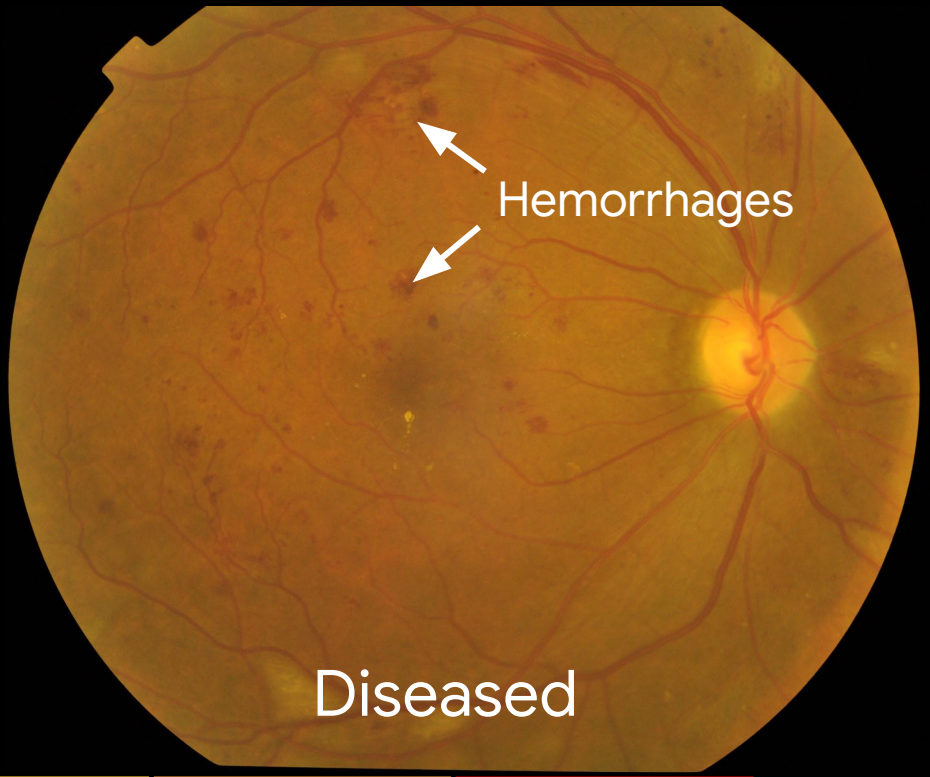
INDIA

Shortage of 127,000 eye doctors

45% of patients suffer vision loss before diagnosis

How DR is Diagnosed: Retinal Fundus Images

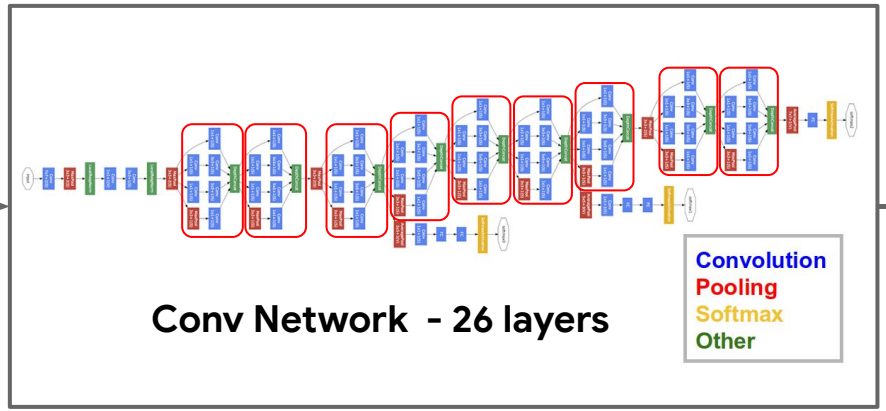
Healthy



Diseased

No DR	Mild DR	Moderate DR	Severe DR	Proliferative DR

Adapt deep neural network to read fundus images

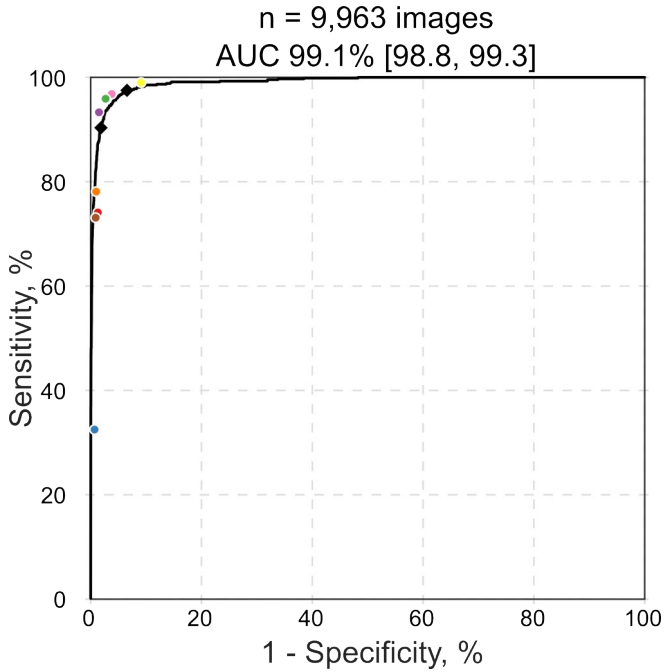


- No DR
- Mild DR
- Moderate DR
- Severe DR
- Proliferative DR
- Image Quality
- L/R eye
- Field of View

JAMA The Journal of the American Medical Association

JAMA | Original Investigation | INNOVATIONS IN HEALTH CARE DELIVERY

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs



F-score

0.95	0.91
Algorithm	Ophthalmologist (median)

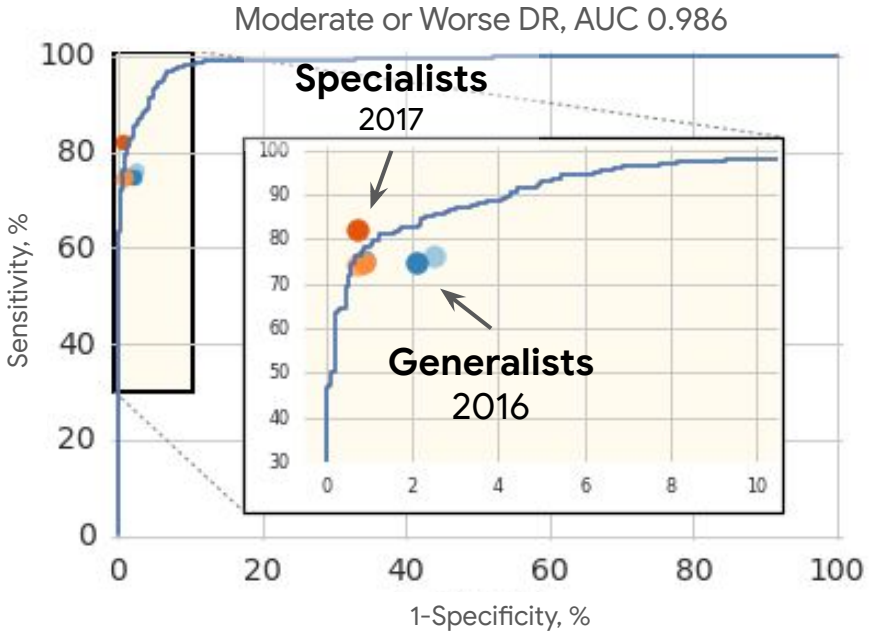
"The study by Gulshan and colleagues **truly represents the brave new world in medicine.**"

Dr. Andrew Beam, Dr. Isaac Kohane
Harvard Medical School

"Google just published this paper in JAMA (impact factor 37) [...] **It actually lives up to the hype.**"

Dr. Luke Oakden-Rayner
University of Adelaide

2016 - On Par with General Ophthalmologists
2017 - On Par with Retinal Specialist Ophthalmologists



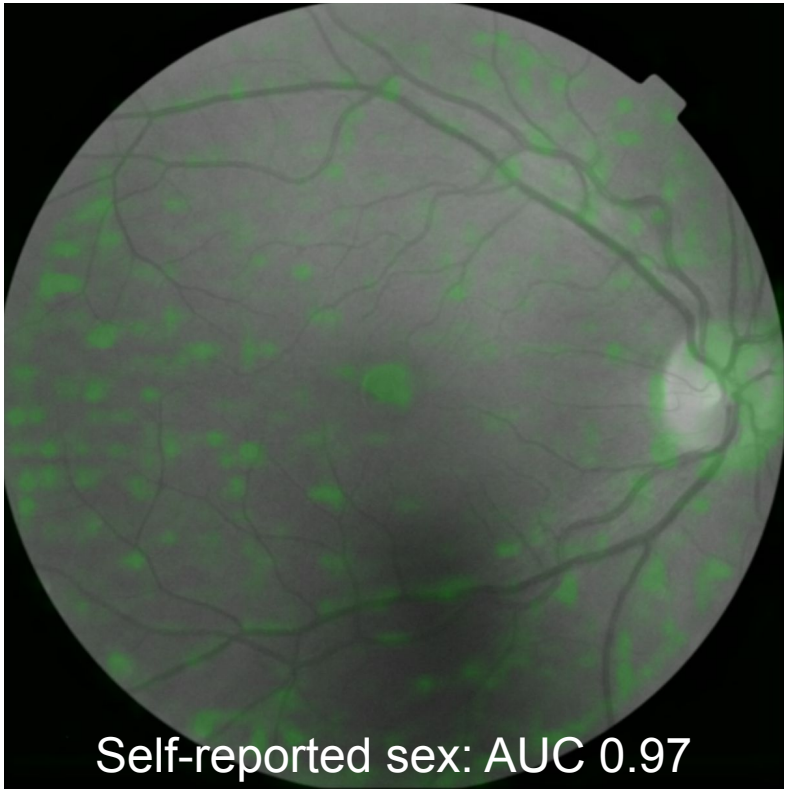
	Weighted Kappa
Ophthalmologists Individual	0.80-0.84
Algorithm	0.84
Retinal Specialists Individual	0.82-0.91

Grader variability and the importance of reference standards for evaluating machine learning models for diabetic retinopathy. J. Krause, *et al.*, *Ophthalmology*, doi.org/10.1016/j.ophtha.2018.01.034

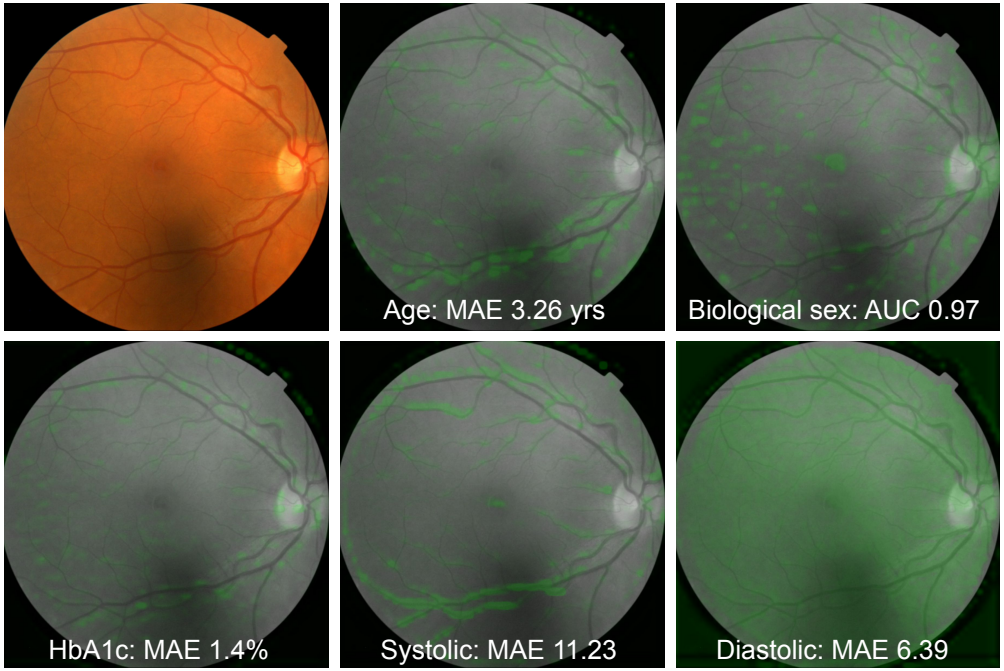
Completely new, novel scientific discoveries

Ophthalmologists can’t do this, so should be no better than flipping a coin (i.e. AUC of 0.50)

Completely new, novel scientific discoveries



Completely new, novel scientific discoveries



Predicting things that doctors can't predict from imaging

—

Potential as a new biomarker

Preliminary 5-yr MACE AUC: 0.7

—

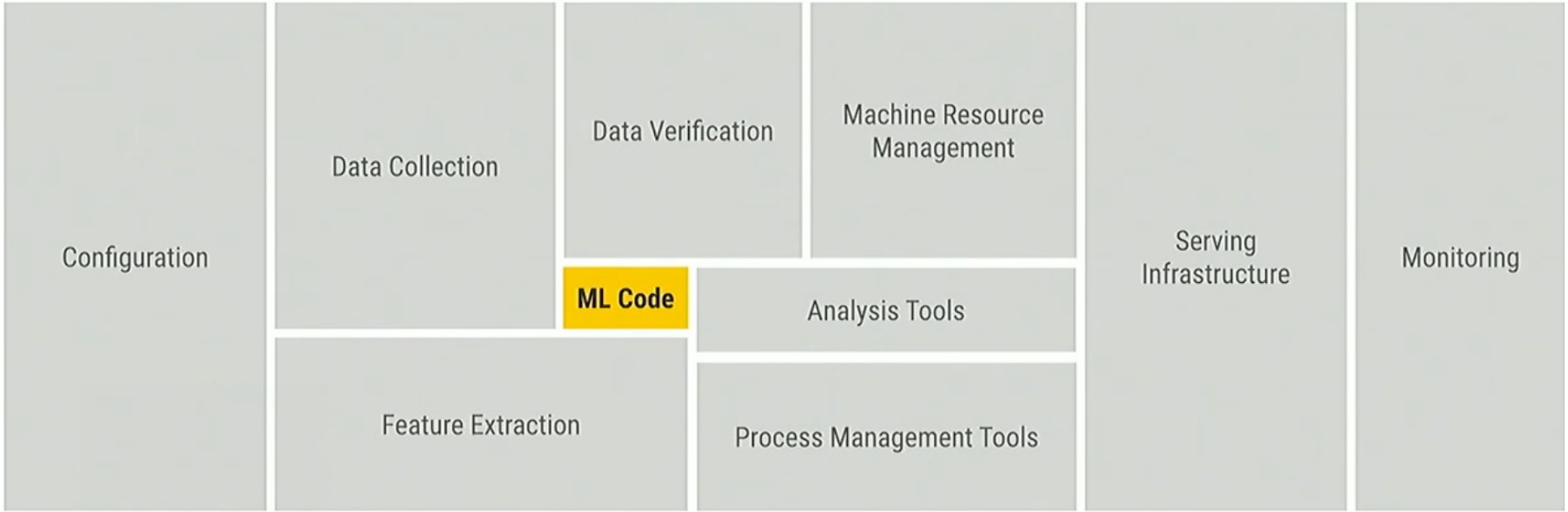
Can we predict cardiovascular risk? If so, this is a very nice non-invasive way of doing so

Can we also predict treatment response?

R. Poplin, A. Varadarajan *et al.* Predicting Cardiovascular Risk Factors from Retinal Fundus Photographs using Deep Learning. *Nature Biomedical Engineering, 2018.*

What’s next?

- AI Research continues to grow.
- Greater Cloud and AI collaboration
  - AI to be a significant driver in Cloud Solution adoption
- IT Problem Detection and Avoidance
- AI and ML Ops


Configuration
Data Collection
Data Verification
Machine Resource Management
Serving Infrastructure
Monitoring
ML Code
Analysis Tools
Feature Extraction
Process Management Tools

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- Talent Squeeze
- Ethics and Bias
- Regulations and Explainability