



# Machine Learning on Mobile

## droidcon Shanghai 2018

linsong



Google Developers  
Experts

# Content

- **Application Cases of ML on Mobile**

  - TF Summit & I/O

- **Trend**

# Coca-Cola AI Application

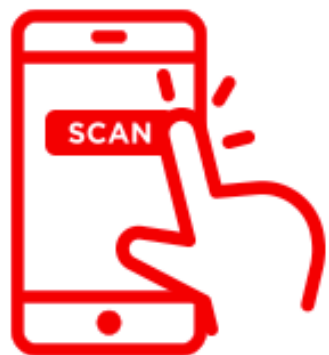
## 用户体验改进

- 14 位字符肉眼识别手动输入改为扫码输入

Introducing a new way to earn perks, experiences and more from Coca-Cola™. Every time you scan the sip & scan icon on your favorite Coca-Cola® products, great things await. Here's how it works:



Type Coke.com in your phone browser



Tap "scan"



Access camera



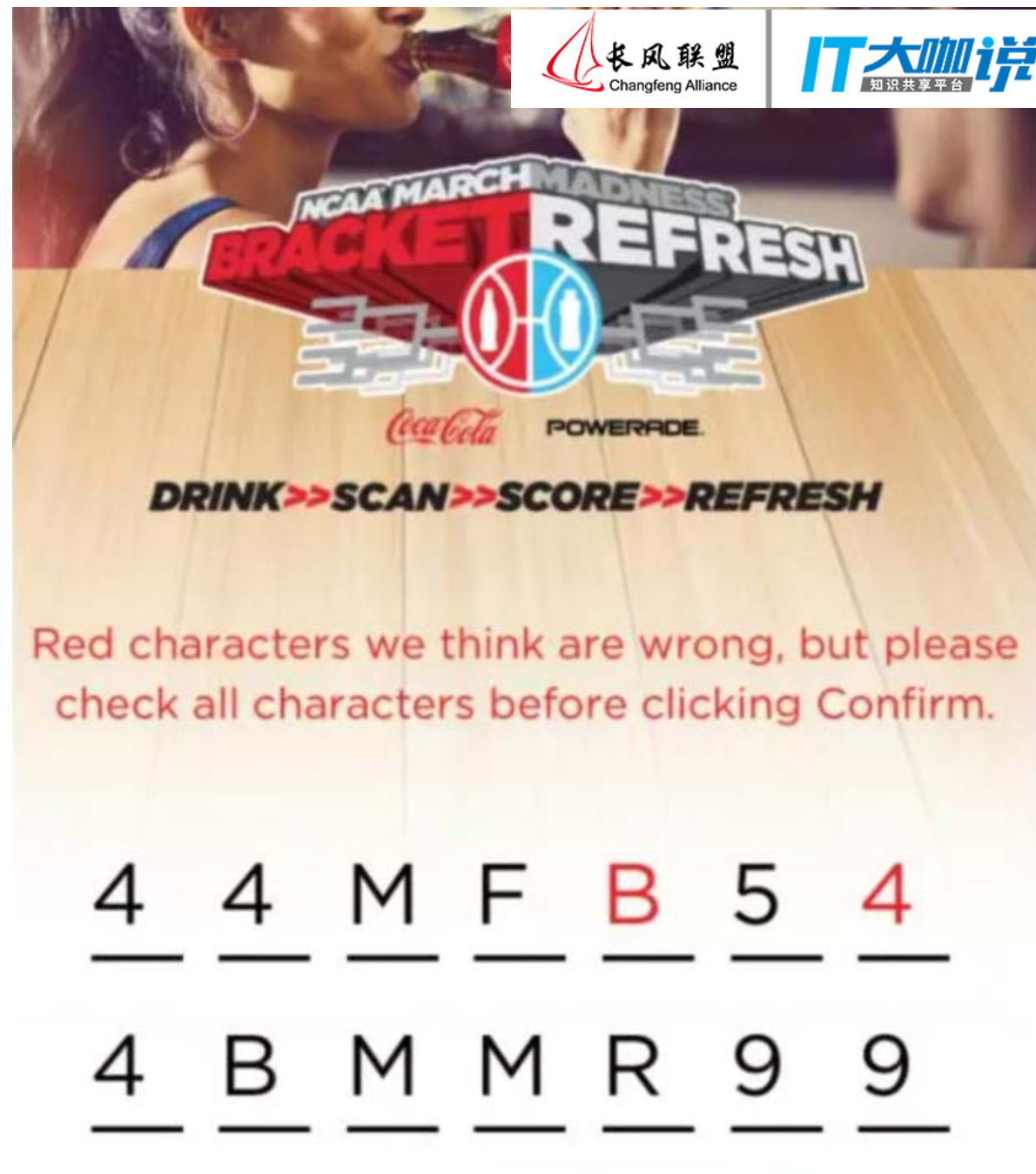
Scan the sip & scan icon



Exciting experiences await you

## 需求

- 快速：产品编码图像处理时间平均一秒
- 准确：95% 的字符串识别准确率，且模型通过主动学习随时间不断改进
- 小型：直接分发到移动应用上，并在模型随时间改进时适应无线更新
- 不同产品的编码介质：不同颜色、材质、包装等的组合



Valid code found: 44MFB544BMMR99



Valid code found: 67R0MJBWHRFKHV



Valid code found: P5HR466W7TT7KL



Valid code found: H96L5HR6BR5JHL



Valid code found: P5HR466W7TT7KL

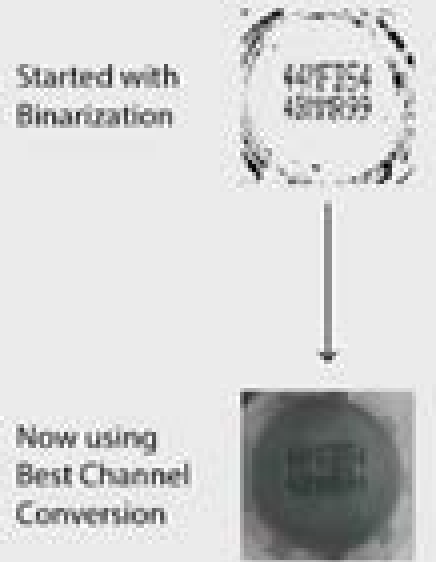


Valid code found: P5HR466W7TT7KL



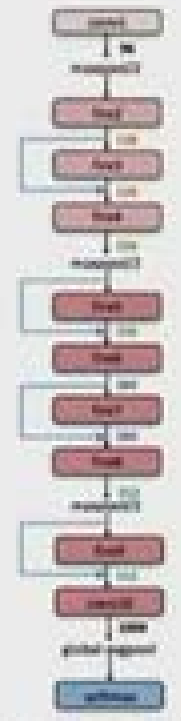
# Improving the model in 3 phases

Improving image normalization...



Reduce model size

Implementing SqueezeNet...



\*Iandola et al., 2016

Improve training efficiency

Using Batch Normalization...

$$\mu_B \leftarrow \frac{1}{m} \sum_{i=1}^m x_i$$

$$\sigma_B^2 \leftarrow \frac{1}{m} \sum_{i=1}^m (x_i - \mu_B)^2$$

$$\hat{x}_i \leftarrow \frac{x_i - \mu_B}{\sqrt{\sigma_B^2 + \epsilon}}$$

$$y_i \leftarrow \gamma \hat{x}_i + \beta \equiv \text{BN}_{\gamma, \beta}(x_i)$$

\*Ioffe & Szegedy, 2015

made the model too large.

prevented the model from converging.

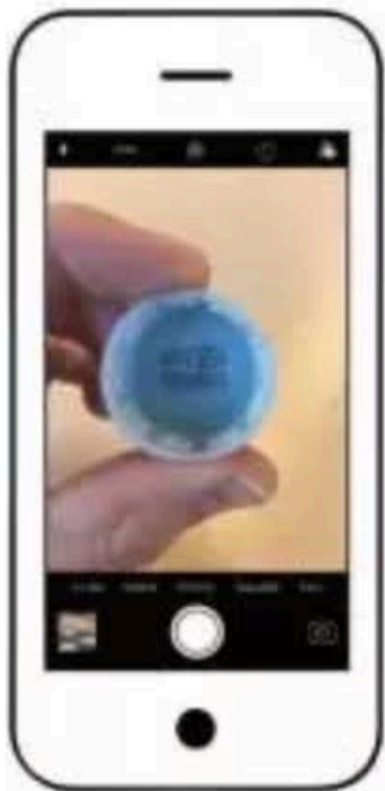
gets the model to converge!

so our model development effort went

through three big iterations initially

model (25-fold decrease)  
with accuracy >95%

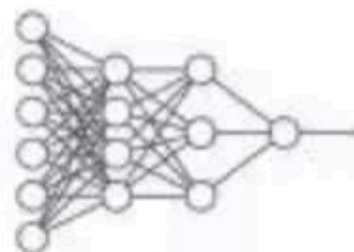
# 1 Take a picture



# 2 Process the image



# 3 Extract the text



A trained Neural Network predicts the 14 pincode values

send corrected code and image back to training



Bingo!  
A valid pincode was predicted



Close!  
We're off by a few characters, ask the user to correct them

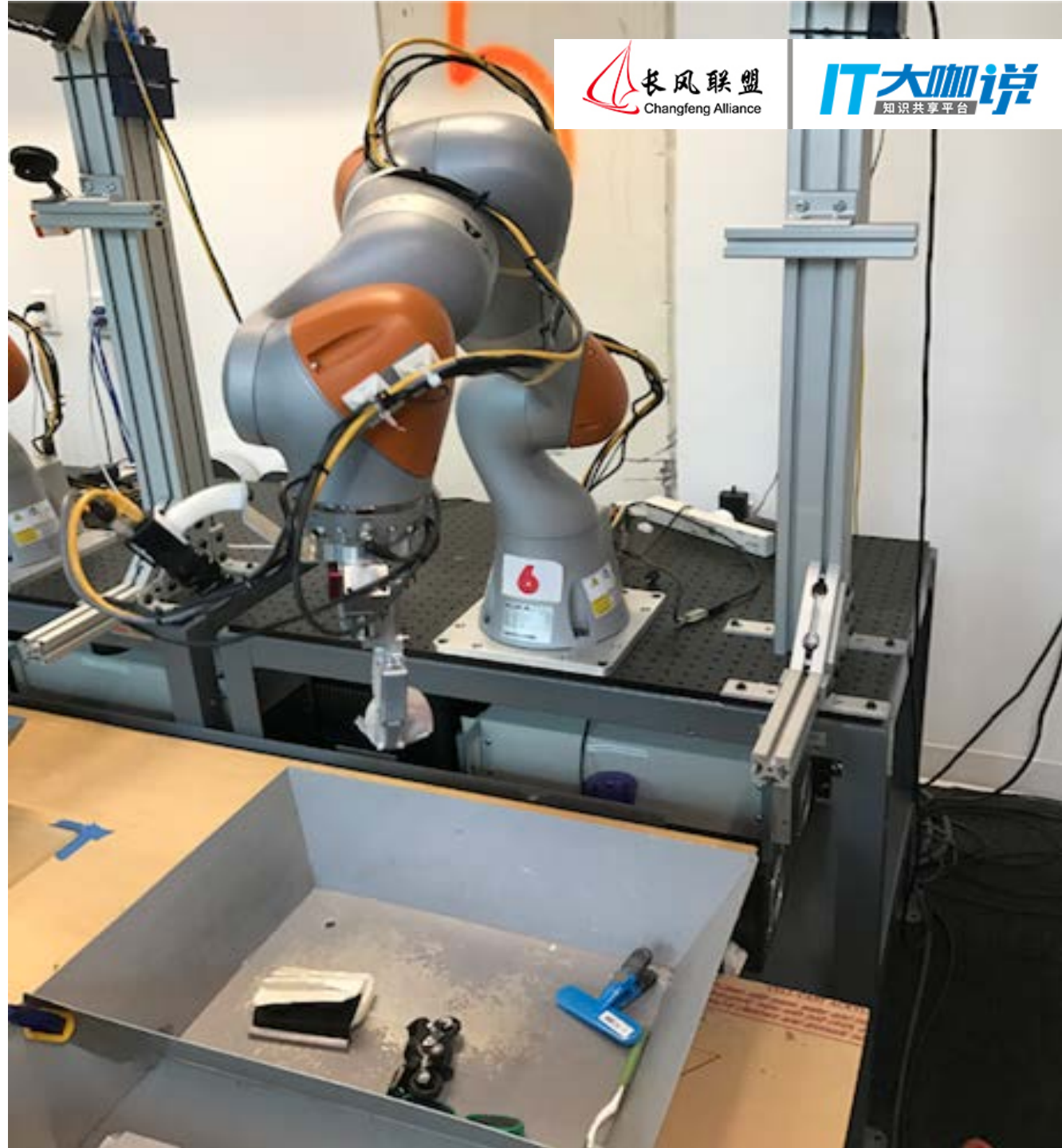
# Real-World Robot

## 需求

- 单眼视觉采集RGB图
- 神经网络控制机械臂

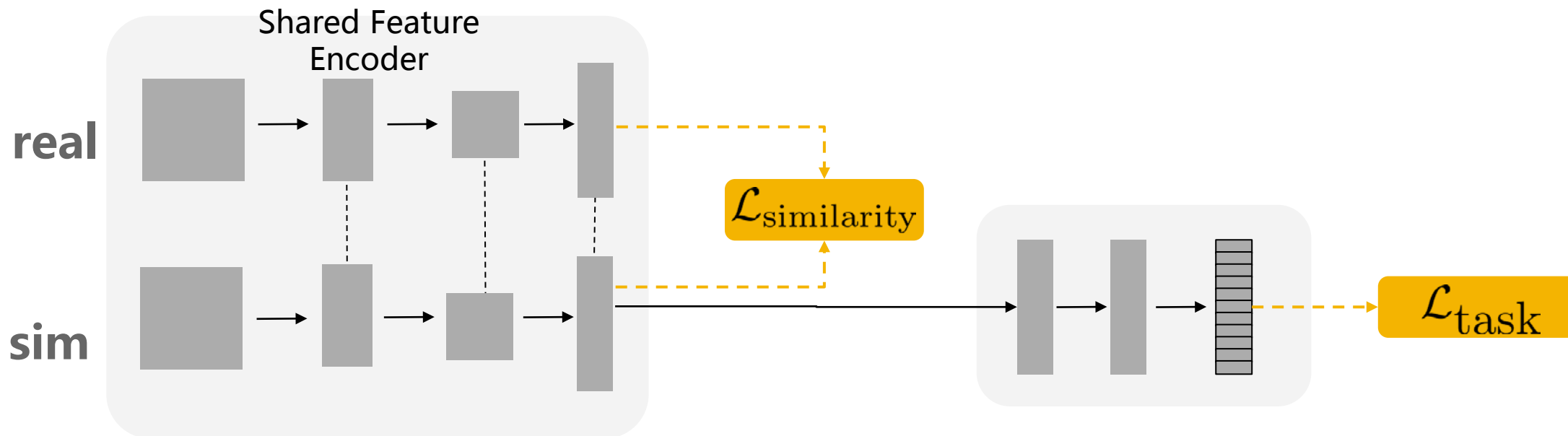
## 问题

- 试验90%----实际23%





# Feature-Level Domain Adaptation

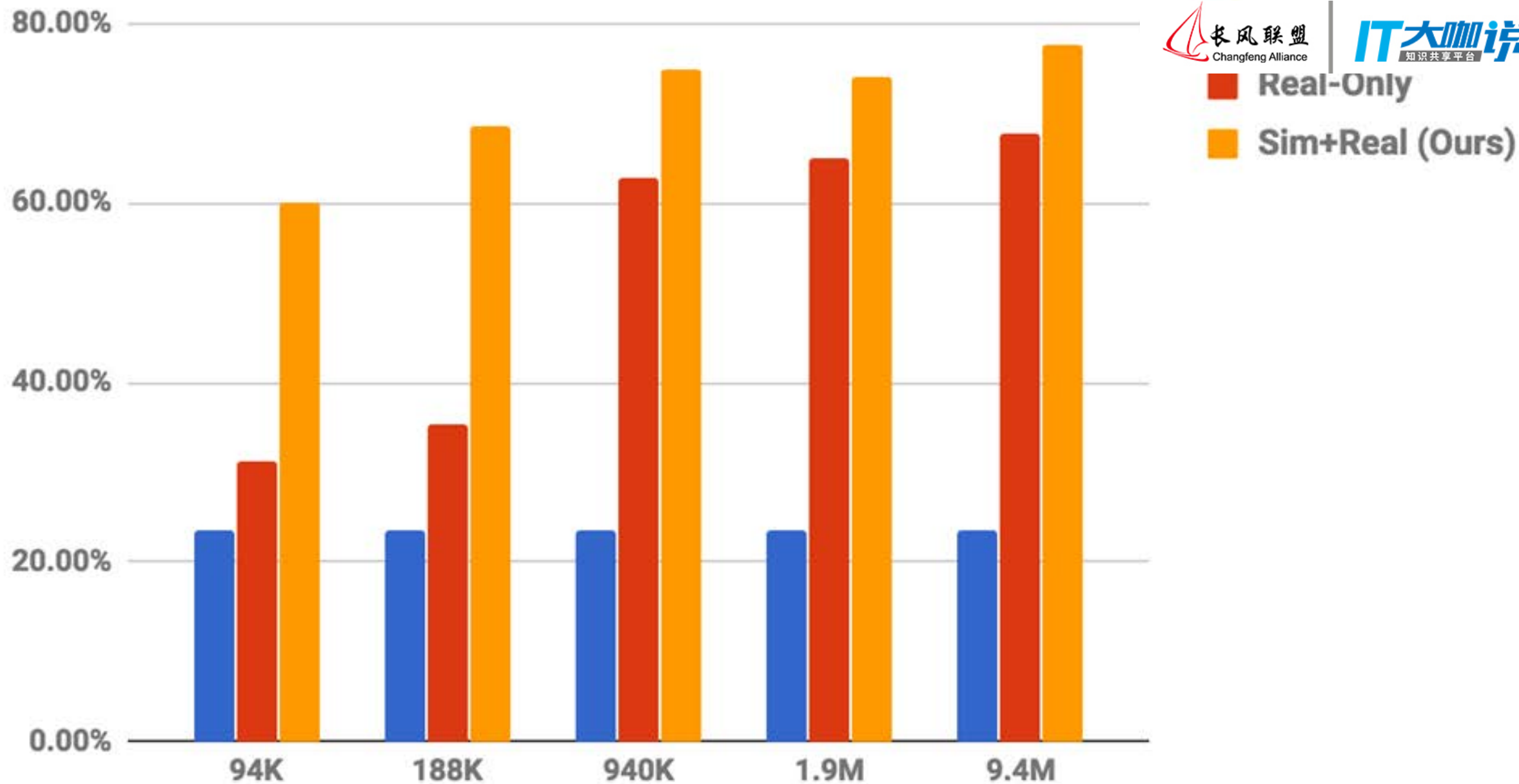


Domain-Adversarial Neural Networks (DANNs)\*

End-to-end learning of **domain-invariant features**, by training a model with an **adversarial domain classifier**

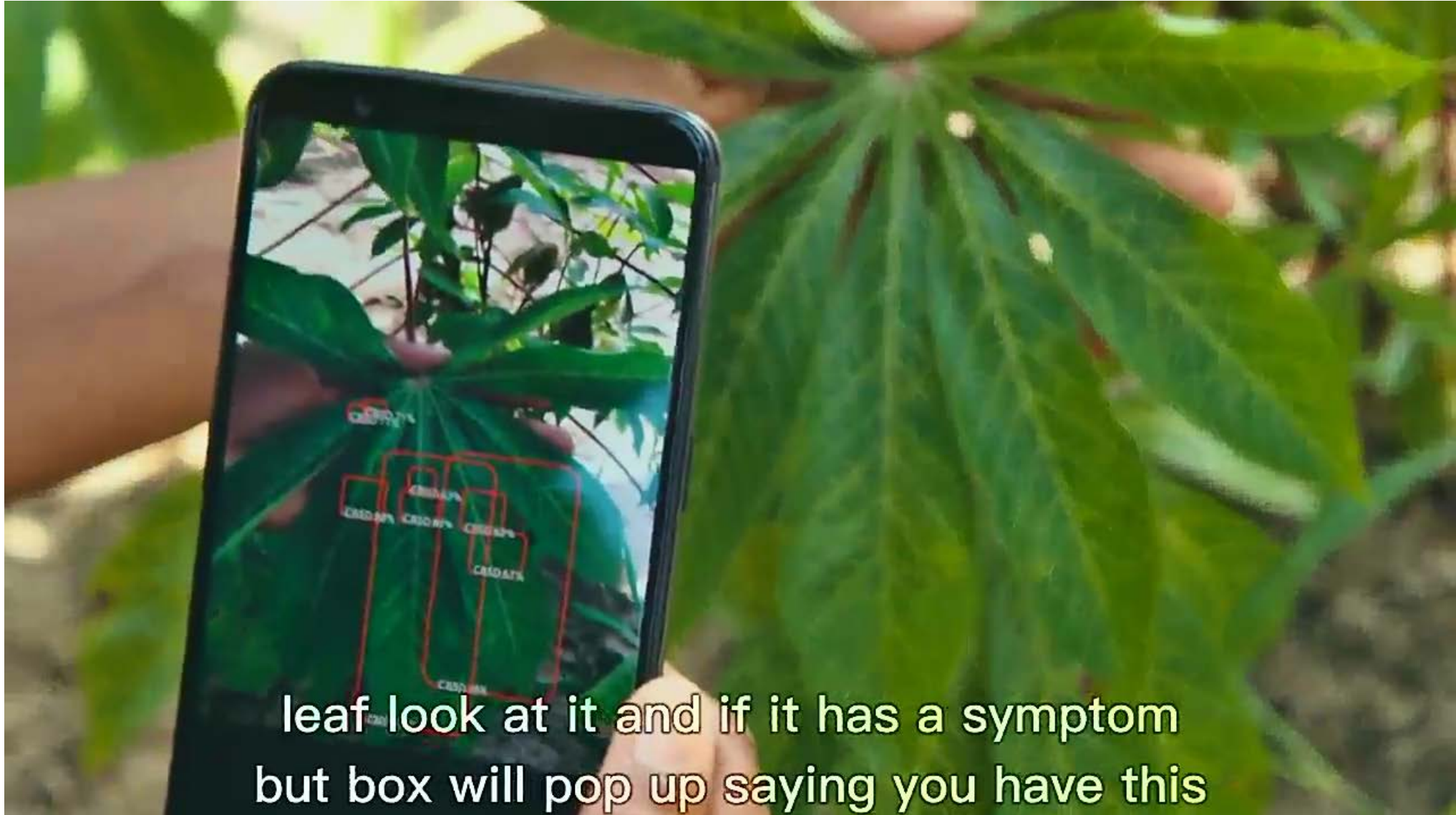
\*(Ganin et al, JMLR 2016)

Grasp Success in the Real World



Number of Real-World Samples Used for Training

# Cassava Disease



leaf look at it and if it has a symptom  
but box will pop up saying you have this



Penn State,  
United States



CIAT, Colombia



CIP, Ecuador



CIP, Peru



IITA, Nigeria



IITA, Zambia



IITA, Mozambique



Bioversity,  
Ethiopia



IITA, Kenya



IITA, Tanzania



CIP, India



CIAT, Vietnam

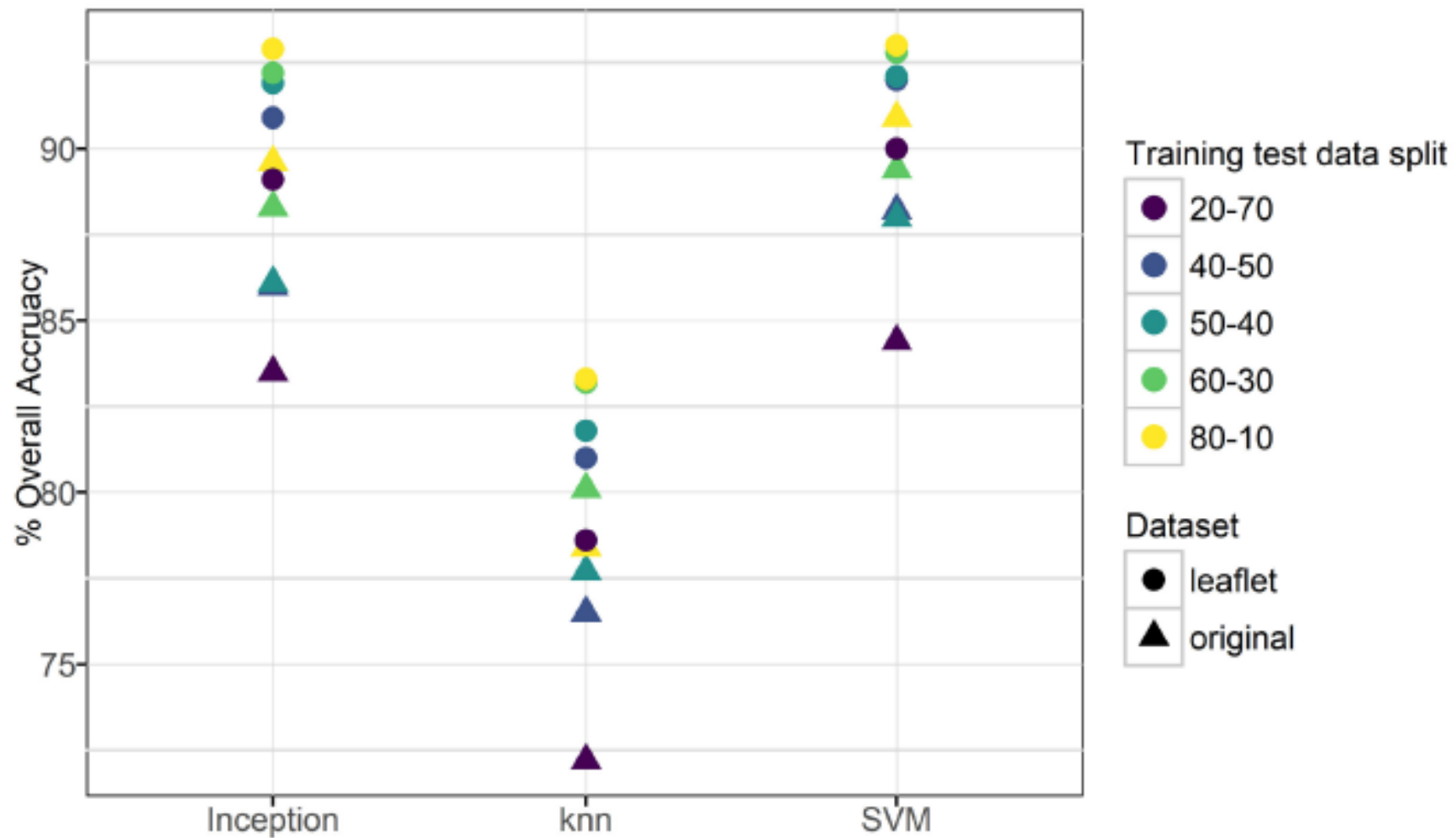
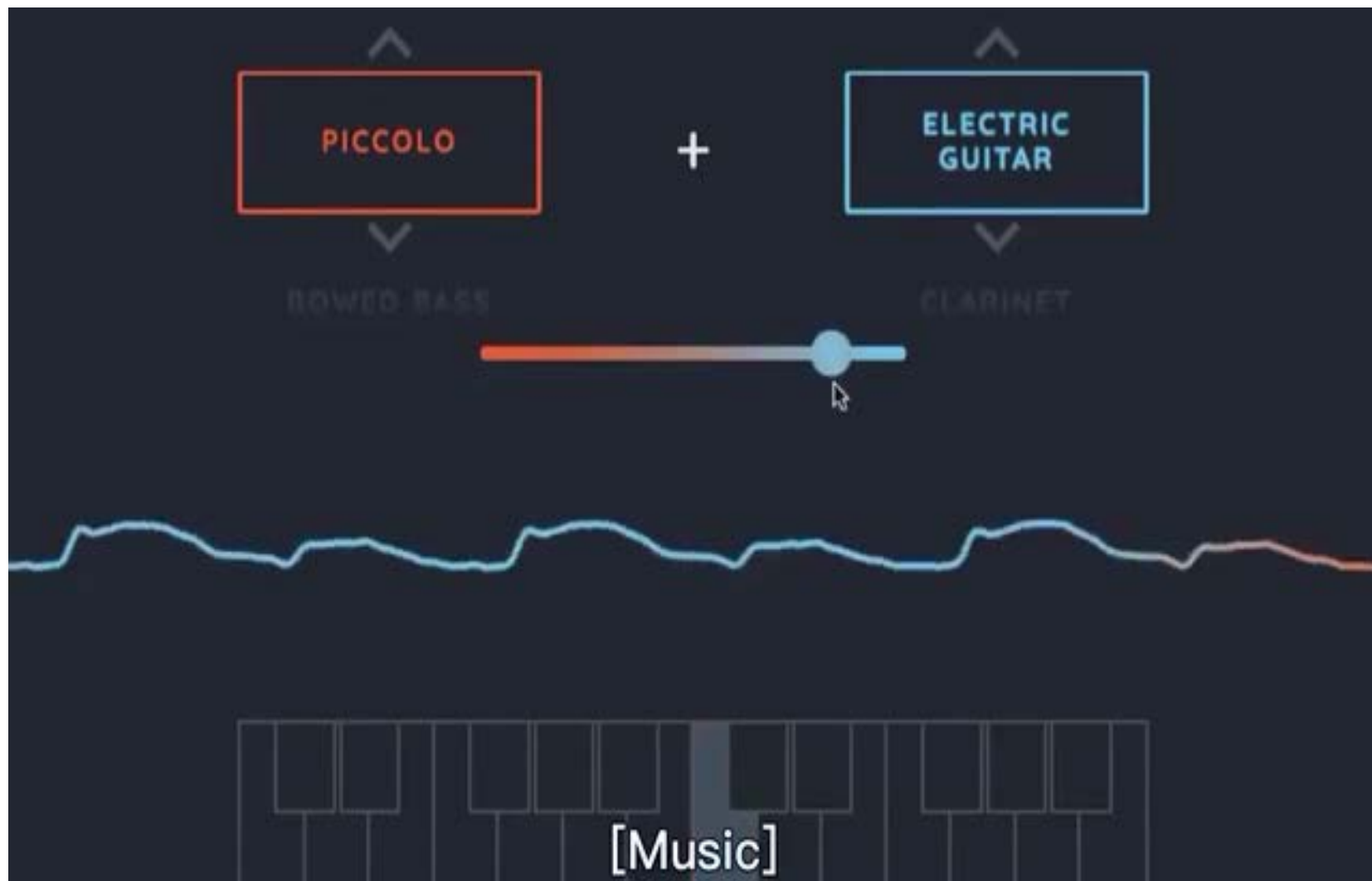


FIGURE 3 | Overall accuracy for transfer learning using three machine learning methods.

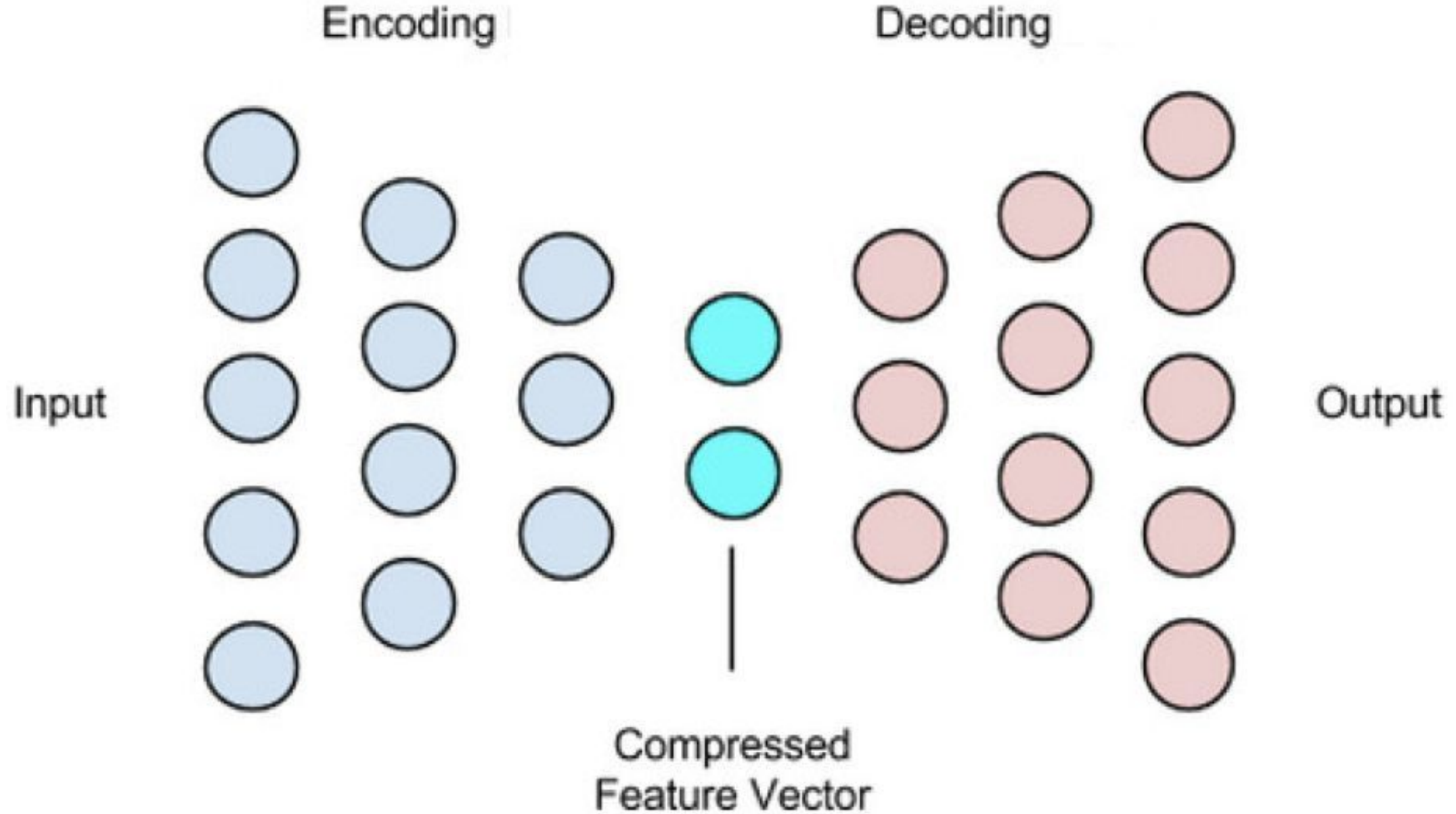
# Project Magenta

## 乐器改变

- Piccolo--Guitar
- Encoder--Decoder

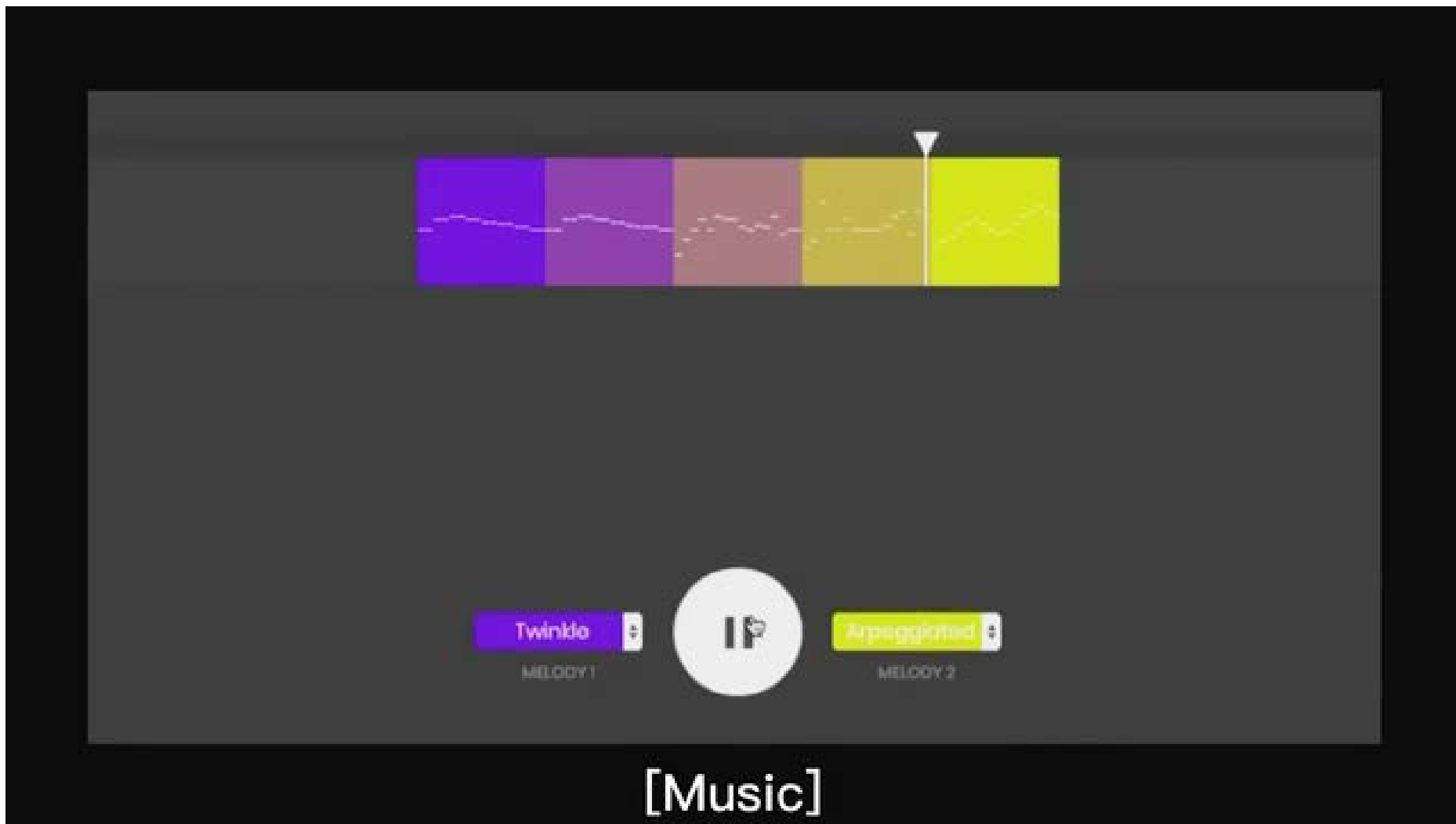


# Deep Autoencoder

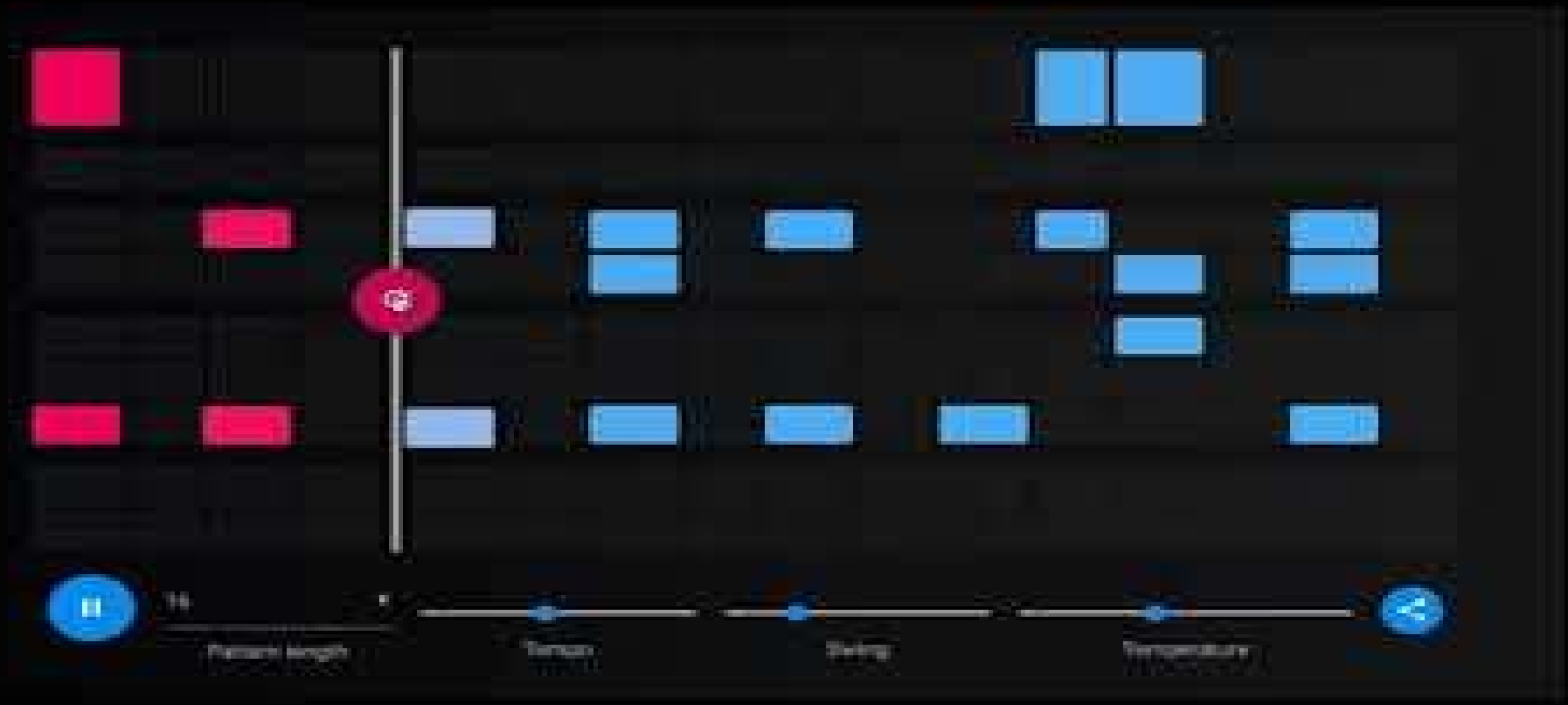


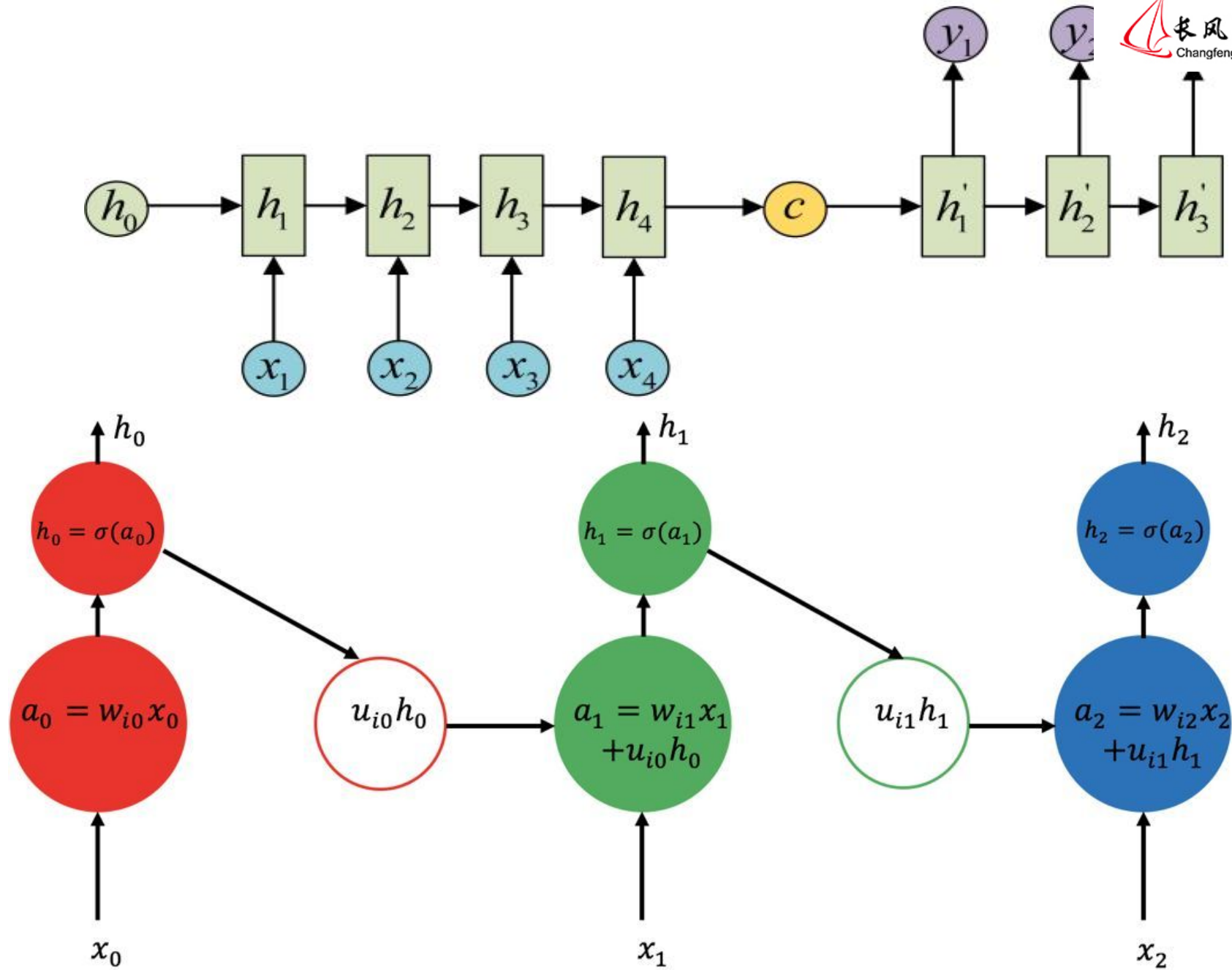
## 风格变换

- Blue rock
- Heavy metal
- Romantic
- Jazz
- Classical
- ...











# # O I O

KEYNOTE

# AI

Prediction  
Medical em  
Readmissi

2018.5.8

长风联盟  
Changfeng Alliance

IT大咖说  
知识共享平台

Emoji Crisis

Gmail

Small compose

Diabetic retinopathy

Cardiovascular risk

Eye scan

Accessibility

Looking to listen

2 speakers yelling at the same time

Morse code → Voice

gboard predictive suggestion

Assistant

Wavenet

6 new voices

John Legend!

Hey, Google just once!

Continued conversation

Ask for multiple actions

Pretty Please

## SMART DISPLAYS

YouTube + YouTube TV

Cooking

video + voice instruction

Maps

Phone visual

Talk + Screen

Google navigation

Google call business ONCE to get holiday hours

Call humans for you

show as search result

Assistant

Hey, Google just once!

Continued conversation

Ask for multiple actions

Pretty Please

## DIGITAL WELLBEING

Android dashboard

Be Internet Awesome

YouTube break reminders

rotif digest

Google News

Briefing

Headlines

New casts

Full coverage

temporal colocality

Same info to everyone

Support publishers

resubscribe to the Google

Android

Intelligence

On-device AI

Adaptive battery

Adaptive brightness

App Actions

Slices

ML Kit

## ANDROID

Google News Initiative

Digital wellbeing

Dashboard

App Timer

Do Not Disturb

Shush

Starred contacts

Wind Down

BND + Grayscale

Simplicity

Single key home button

Swipe up

side snap = recents

Soft Selection in overview

Volume control

Rotation

## MAPS

For You

Trending

Your match

Group planning

Shortlist

Vote

Local businesses

Schedule + Book

Maps AR walking map

camera live view

Augmented maps

Smart text selection

Style match

Real-time results

## WAYMO

AI

Perception

Camera · lidar · radar

detect pedestrians & Behavior

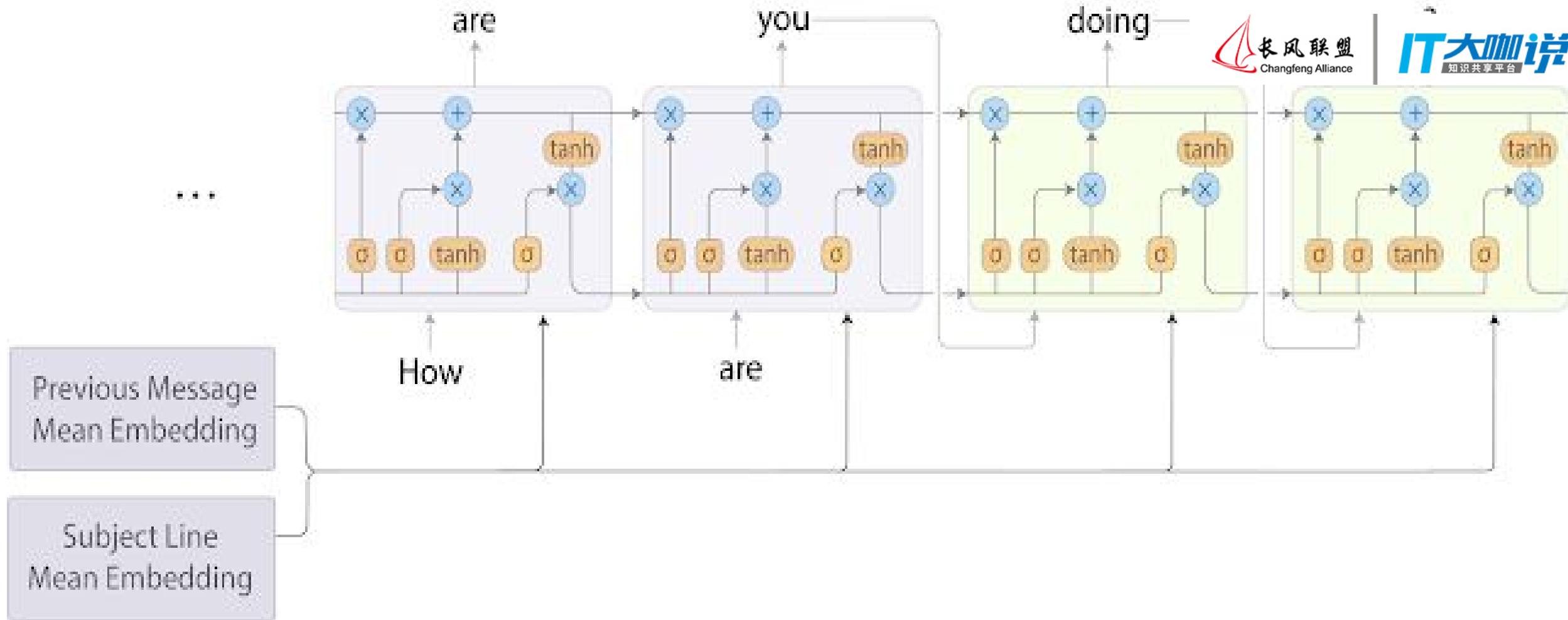
Waymo

6M on public roads

5B in simulation

Drive in snow

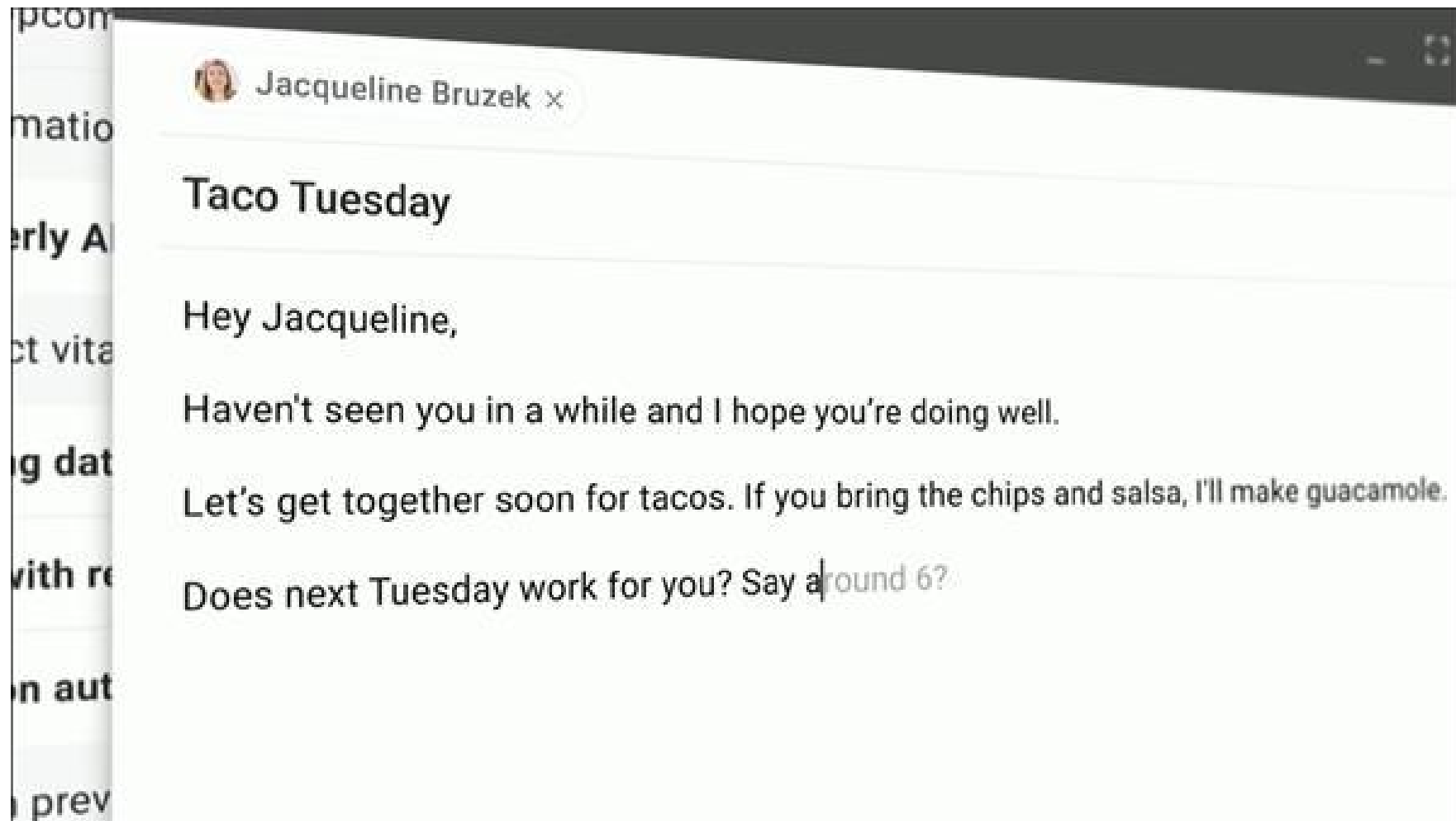
by @



- 预测：下一个词---上下文（主题、收件人、正文...）
- **BoW**模型和**RNN-LM**模型相结合
- 不必要单词的 处理

# Email Smart Compose

- 延迟：模型复杂性和预测速度上作出平衡，就显得尤为重要。
- 规模：14亿用户量，微妙的上下文差异中进行个性化的自动补全功能建议。
- 推荐“you might use”的下文。
- **Simply Confirm !**



# Voice Assistant



- Wavenet from DeepMind
- 6种“人类声音”
- Attention 机制

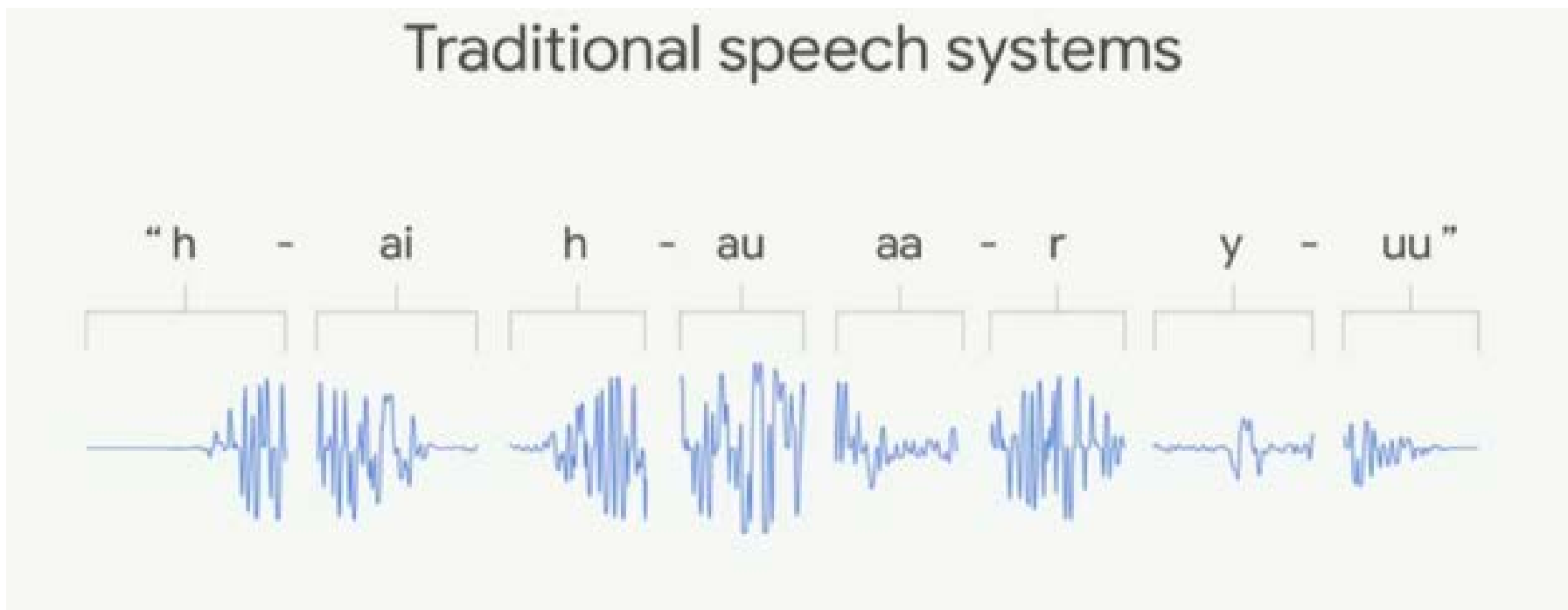
# Wavenet

“Hi, how are you?”



we are adding as of today six new voices

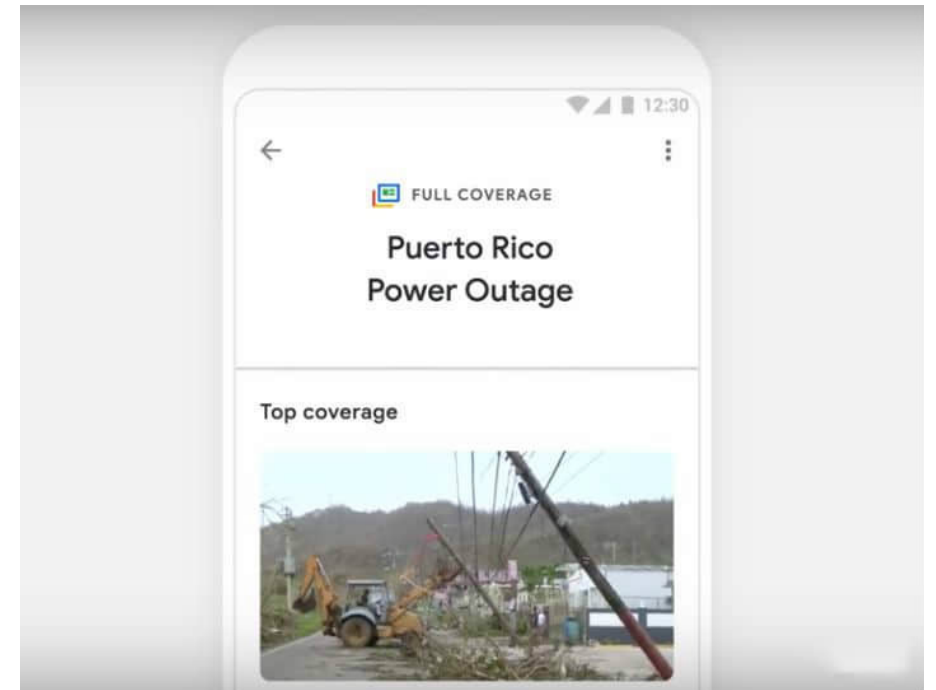
# Voice Assistant - RNN



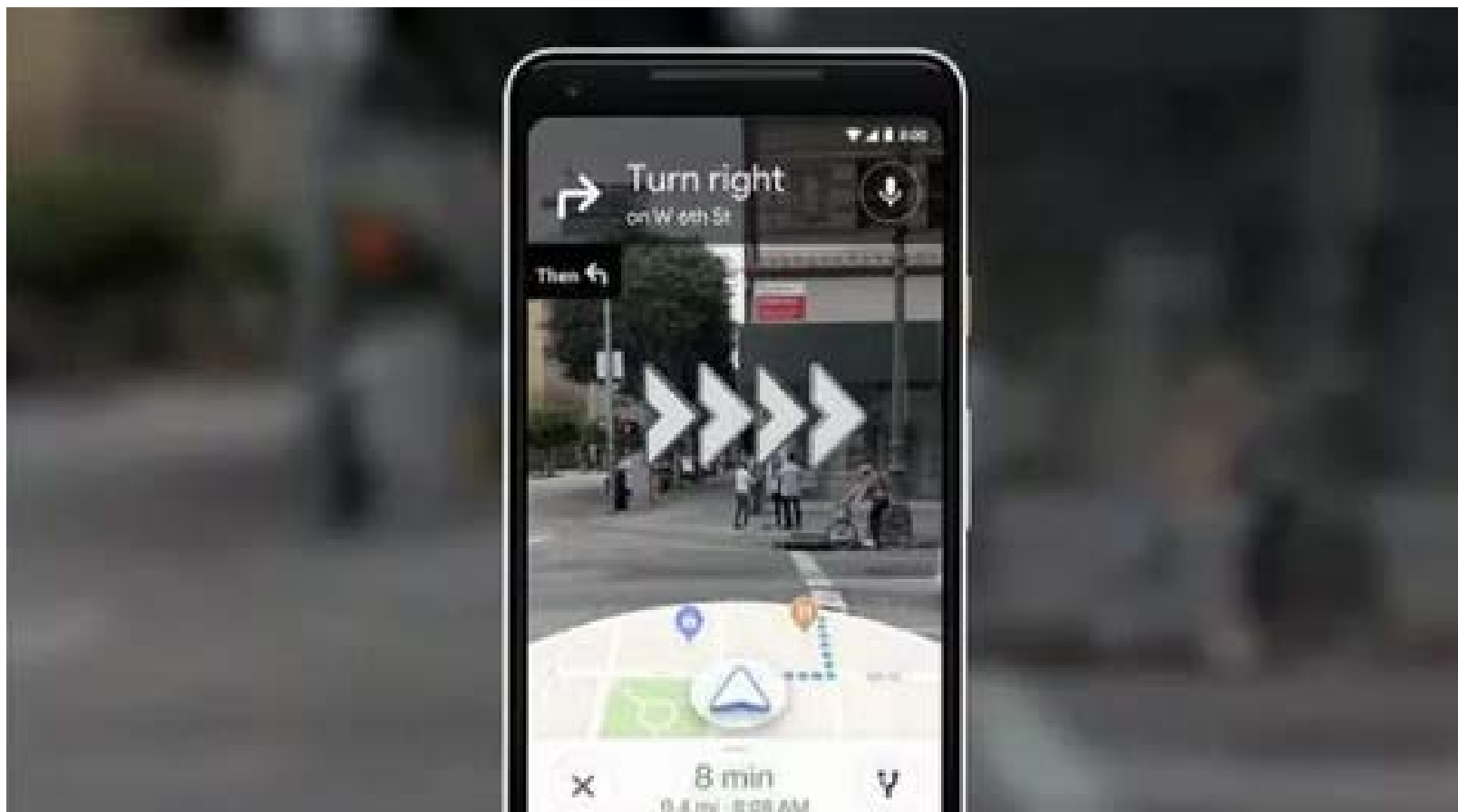


# Google News

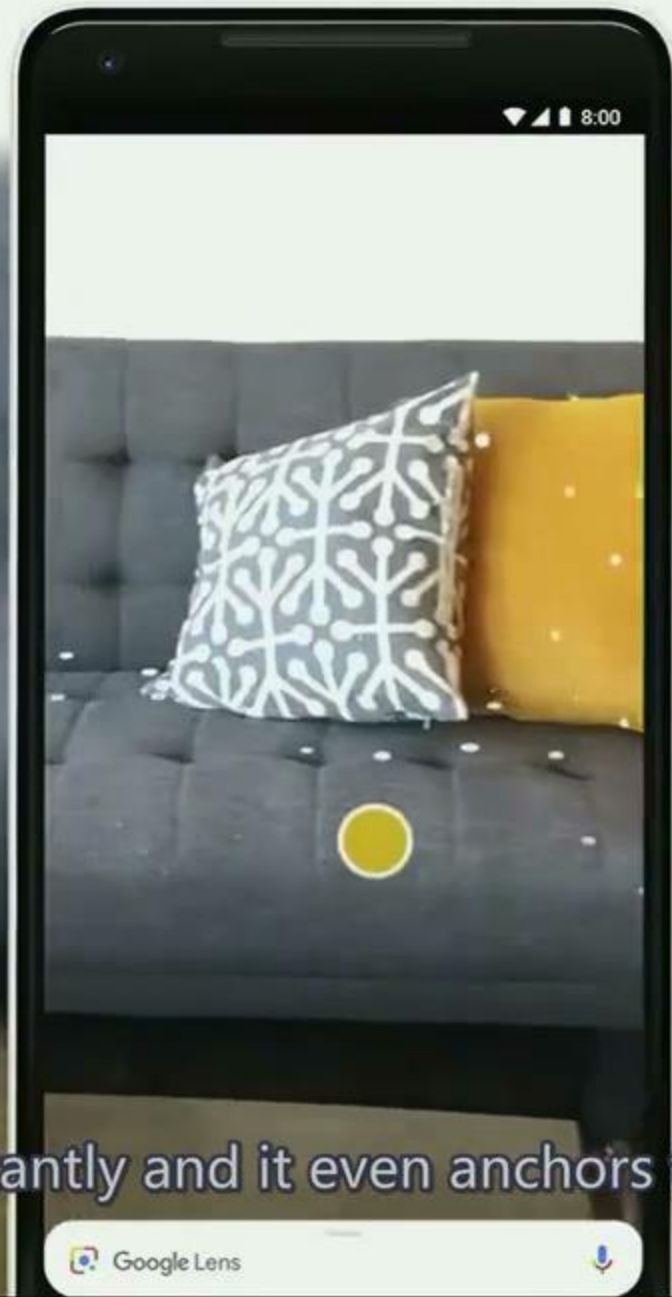
- “For You” 5个可能感兴趣的推荐
- “Newscasts”汇集不同的新闻源推荐单一主题
- “Full Coverage” 深度覆盖
- NLP Based



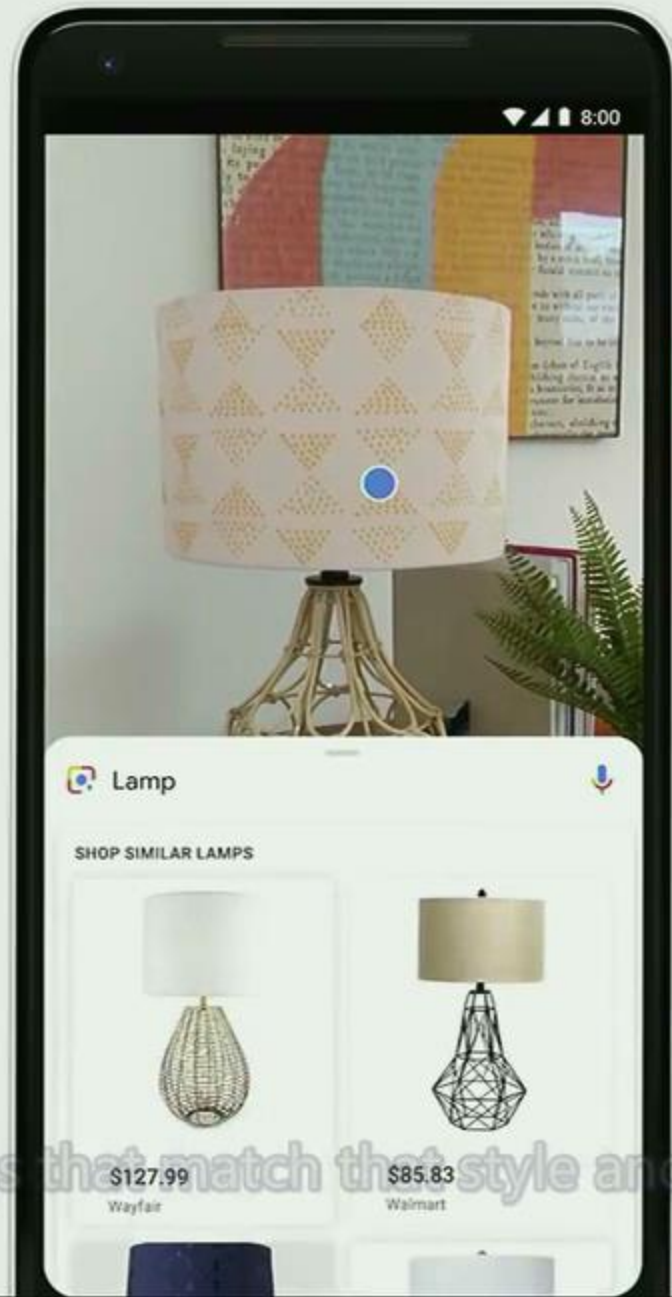
# Google Maps



- Personalized recommendation for route or restaurant



instantly and it even anchors that



things that match that style and now

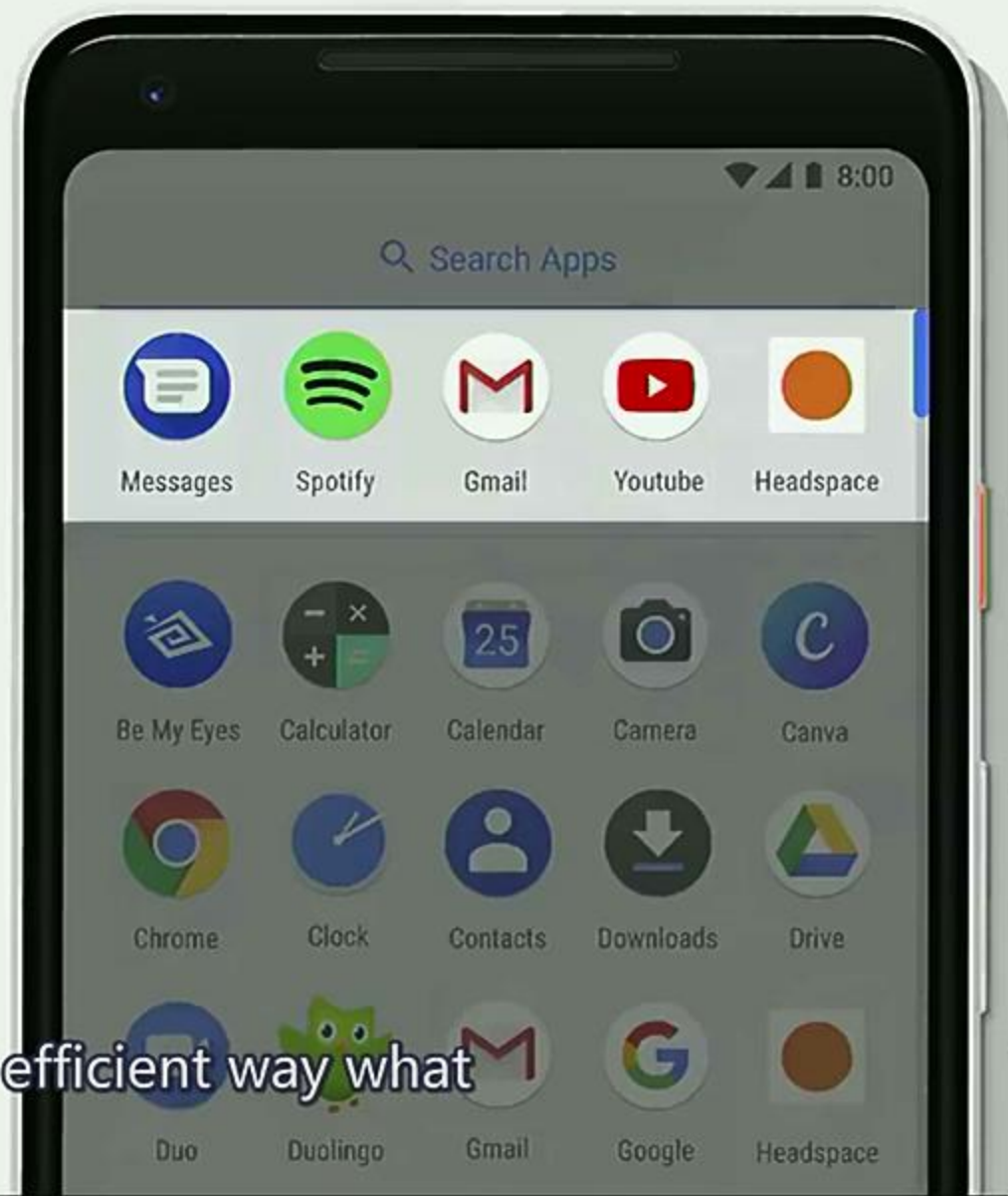
# Android P



- AI helps to shut down not-in-use app to increase battery sustainability

60%

prediction rate



you in a power efficient way what

# Digital Wellbeing

## How we can help you



Understand  
your habits



Focus on  
what matters



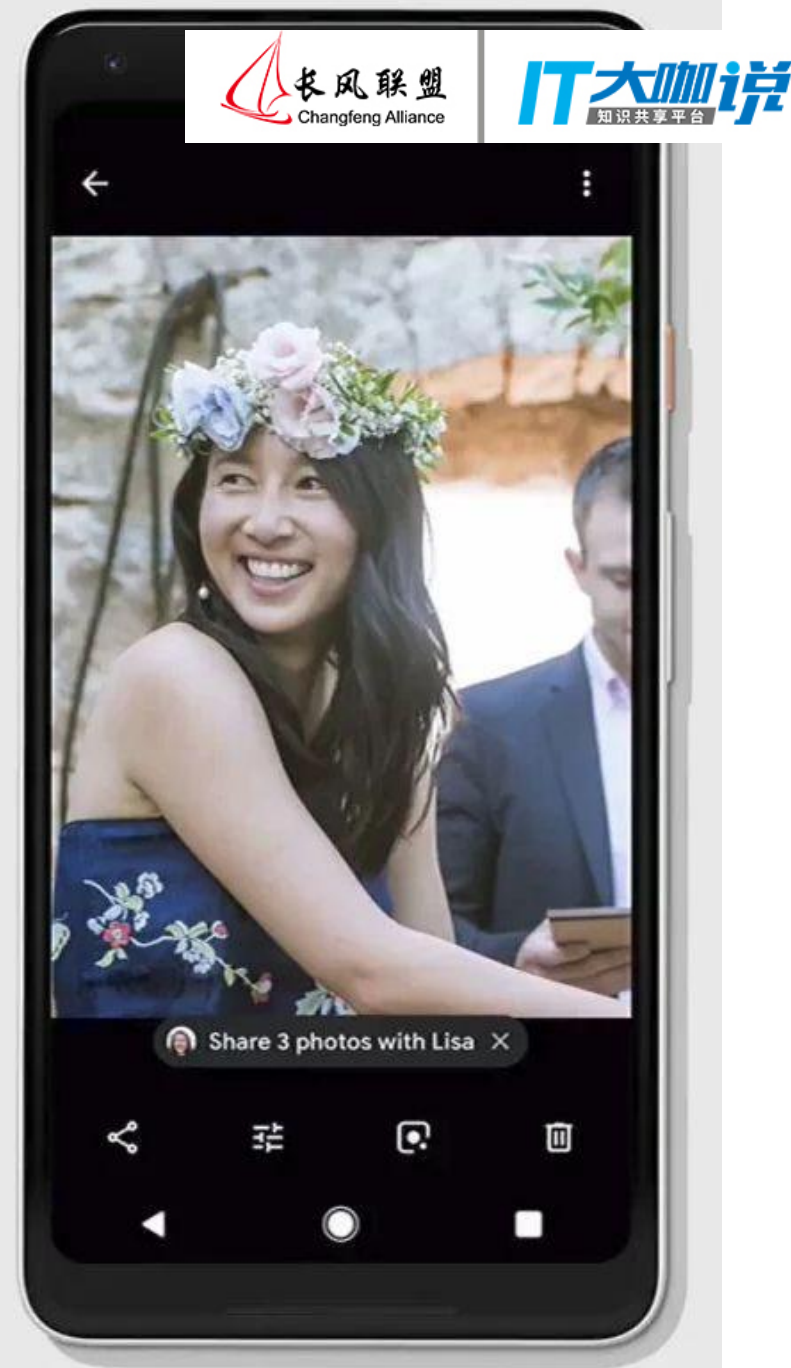
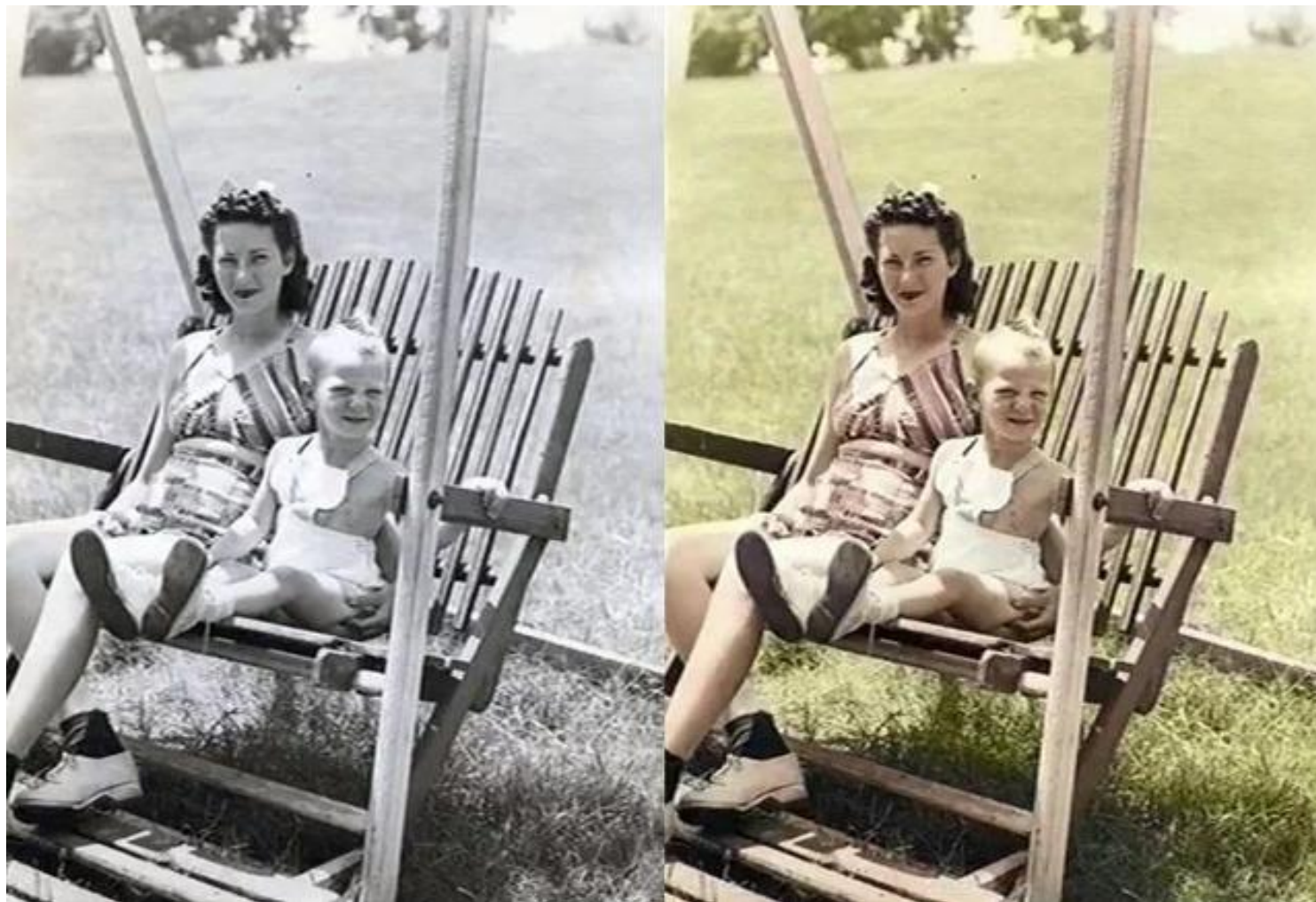
Switch off and  
wind down



Find balance  
for your family

on what matters switch off when you need

# Colorize & Suggested Actions



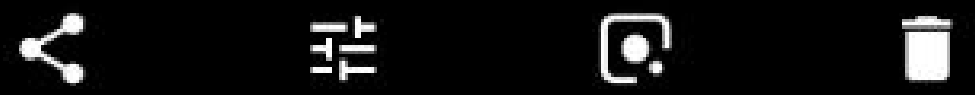




gadgets360.com

gadgets360.com

✦✦ Fix brightness ✕



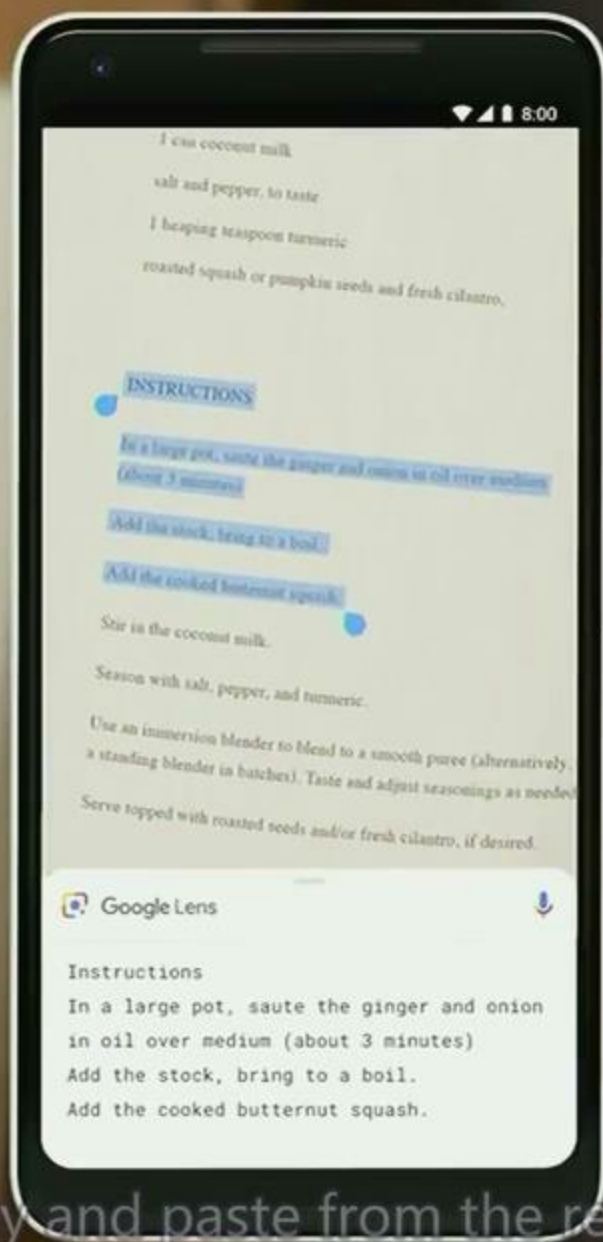
gadgets360.com

gadgets360.com

You can undo changes after saving

CANCEL

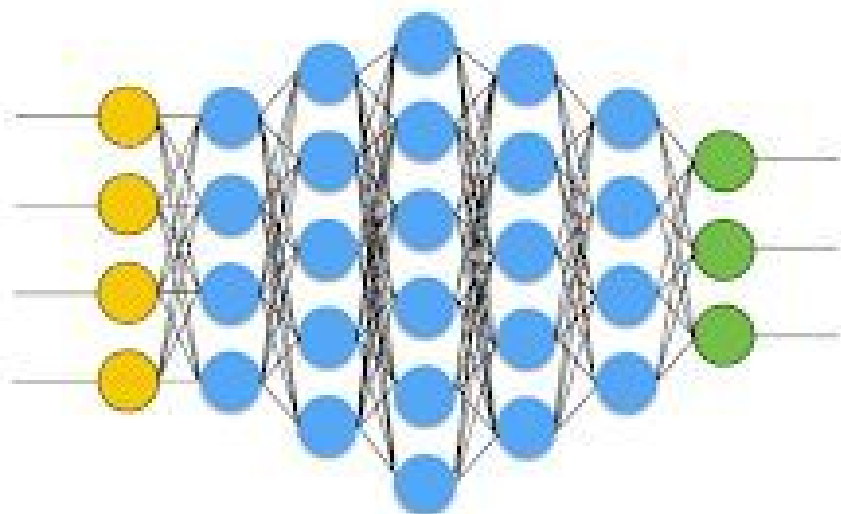
SAVE



like copy and paste from the real world

# Learn2Compress

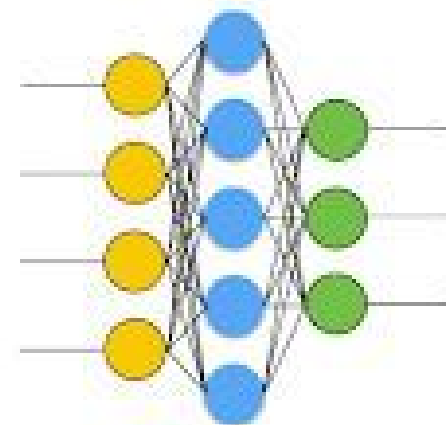
Input Model



 TensorFlow

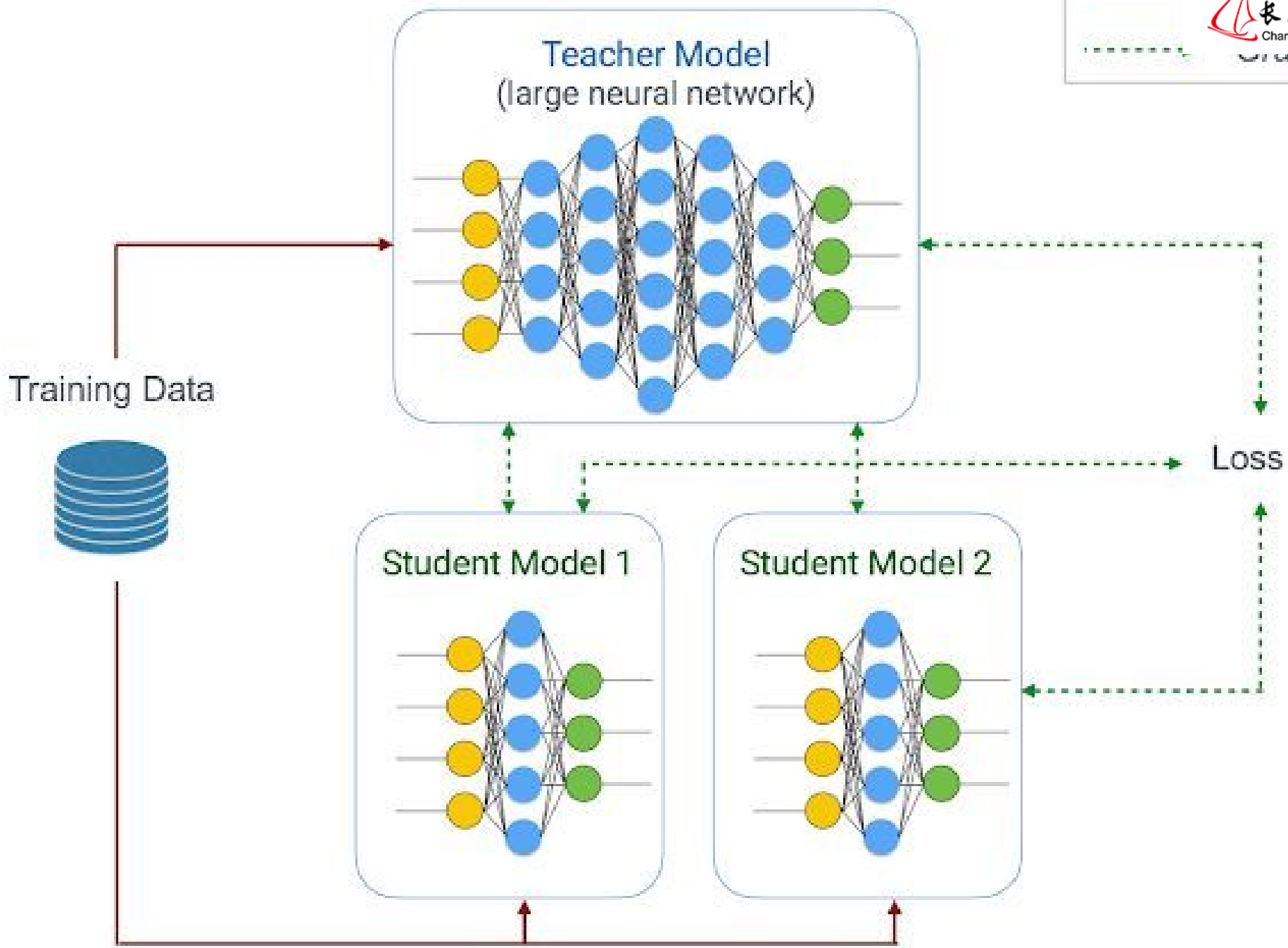
Learn2Compress

Output Model  
(custom *small & fast*  
on-device ML model)



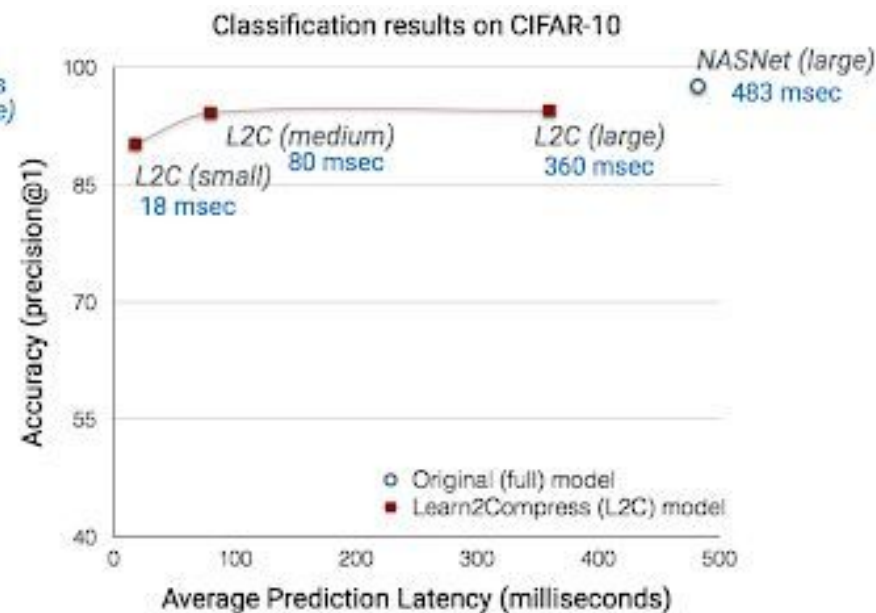
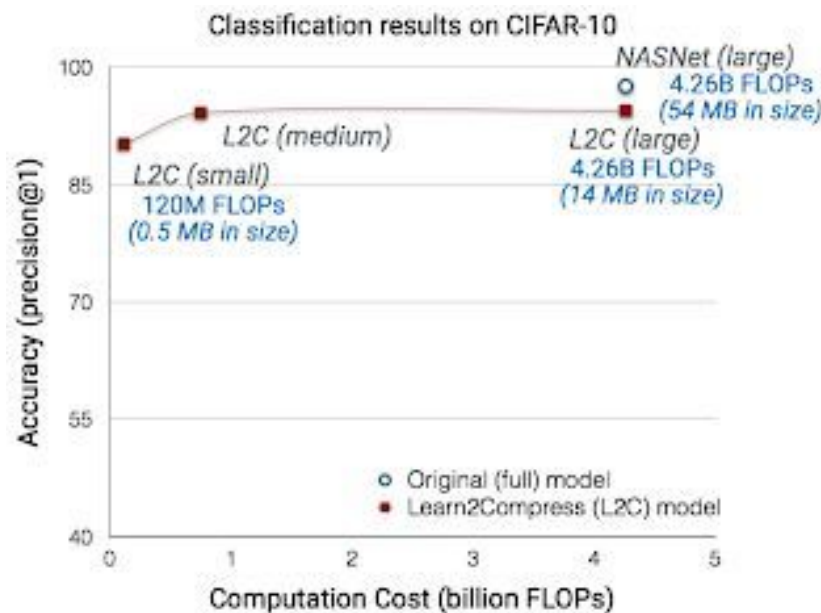
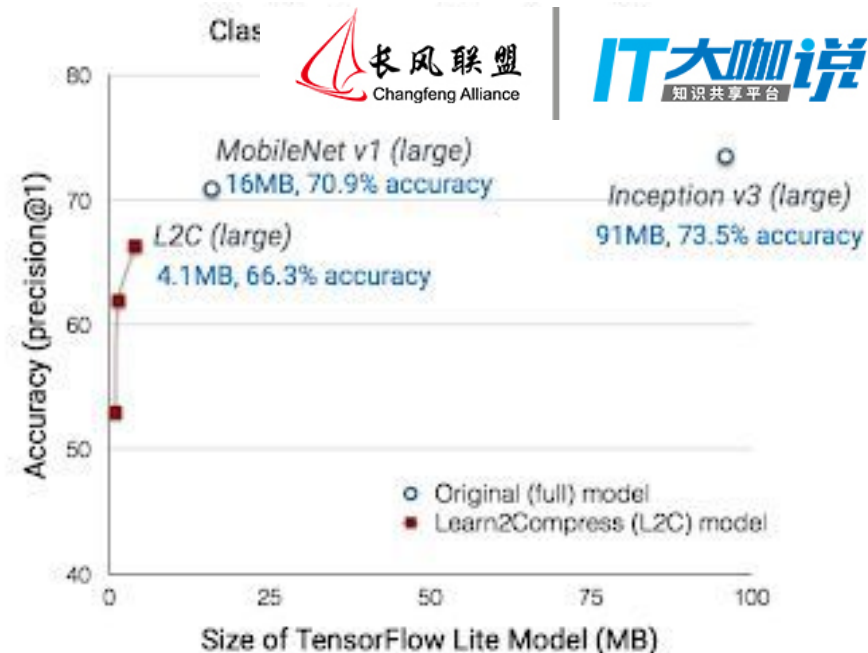
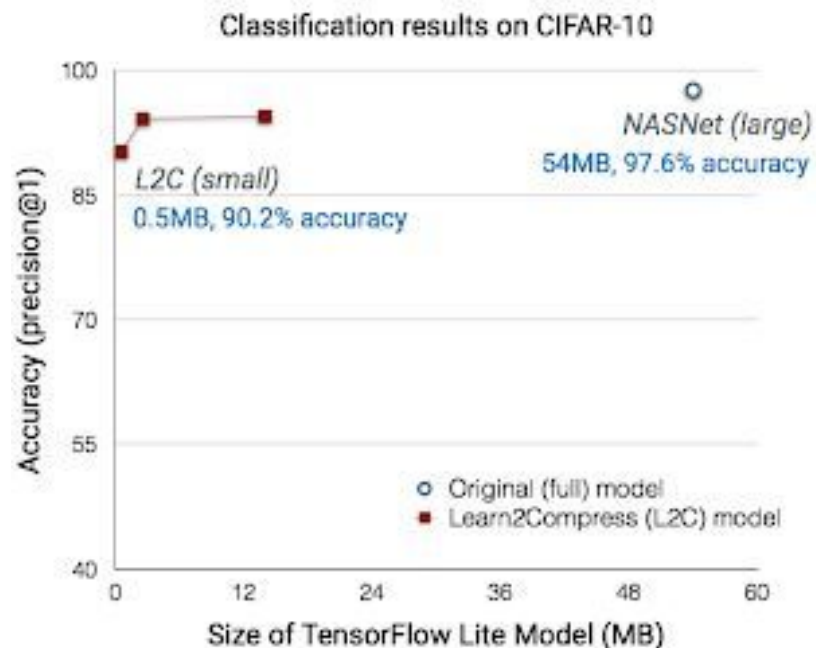
 TensorFlow Lite

- “TensorFlow” ----“TensorFlow Lite”
- Mobile device application



# 性能

- 110% 训练时间
- 70%-90% 准确率
- 1-10% 模型大小
- ~3% 预测成本



( FLOP here is equivalent to 2 \* MAC, where MAC refers to multiply-accumulate operation )

DEVELOP

Authentication

Database

Storage

Hosting

Functions

ML Kit

STABILITY

Crashlytics

Performance

Test Lab

ANALYTICS

Dashboard

Events

Audiences

Attribution

# ML Kit

APIS

CUSTOM

USAGE



Cloud and on-device processing

[View Cloud API usage](#)



## Text recognition



Recognize and extract text from images

[GET STARTED](#)



## Face detection



Detect faces and facial landmarks

[GET STARTED](#)



## Barcode scanning



Scan and process barcodes

[GET STARTED](#)



## Image labeling



Identify objects, locations, activities, animal species, products, and more

[GET STARTED](#)

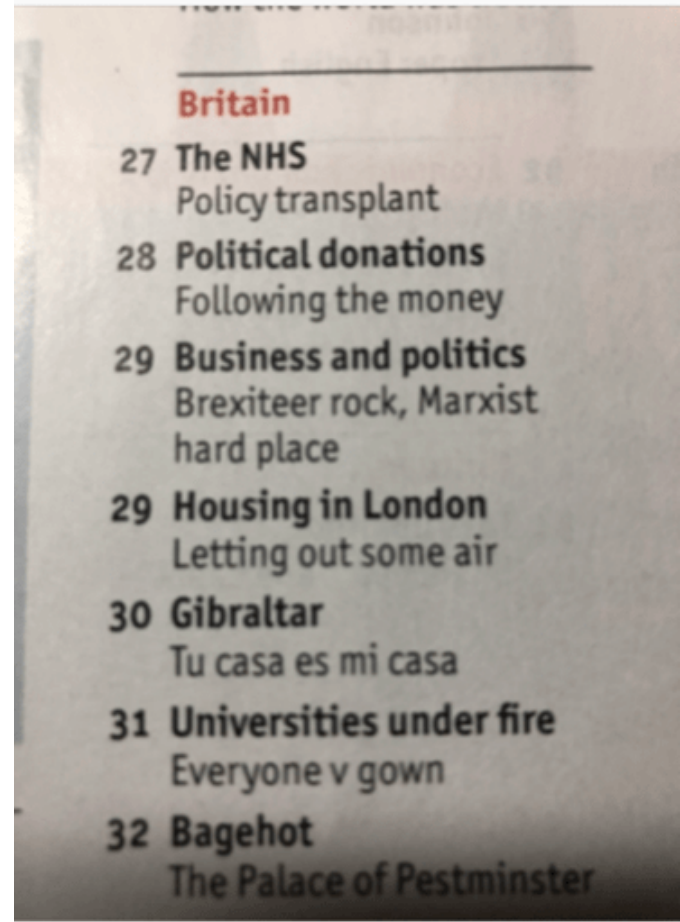


## Landmark recognition

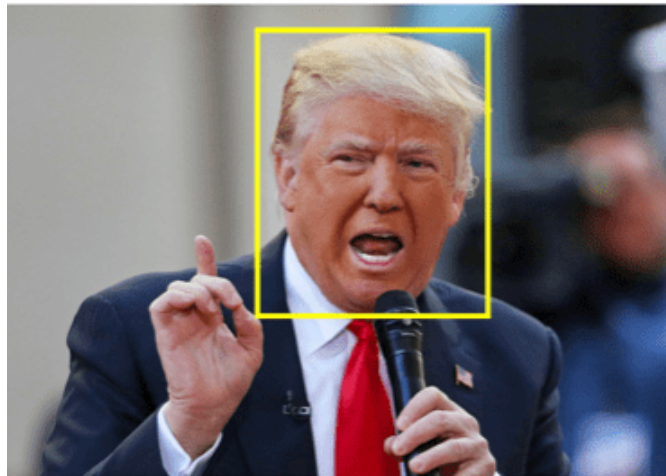


Identify popular landmarks in an image

[GET STARTED](#)



29 Housing in London 30 Gibraltar 31 Universities under fire 32 Bagehot 27 The NHS 28 Political donations The Palace of Pestminster Following the money Business and politics Brexiteer rock, Marxist hard place Letting out some air Tu casa es mi casa Everyone v gown Britain Policy transplant



Frame: (422.785034179688, 43.44580078125, 391.827392578125, 483.737548828125)

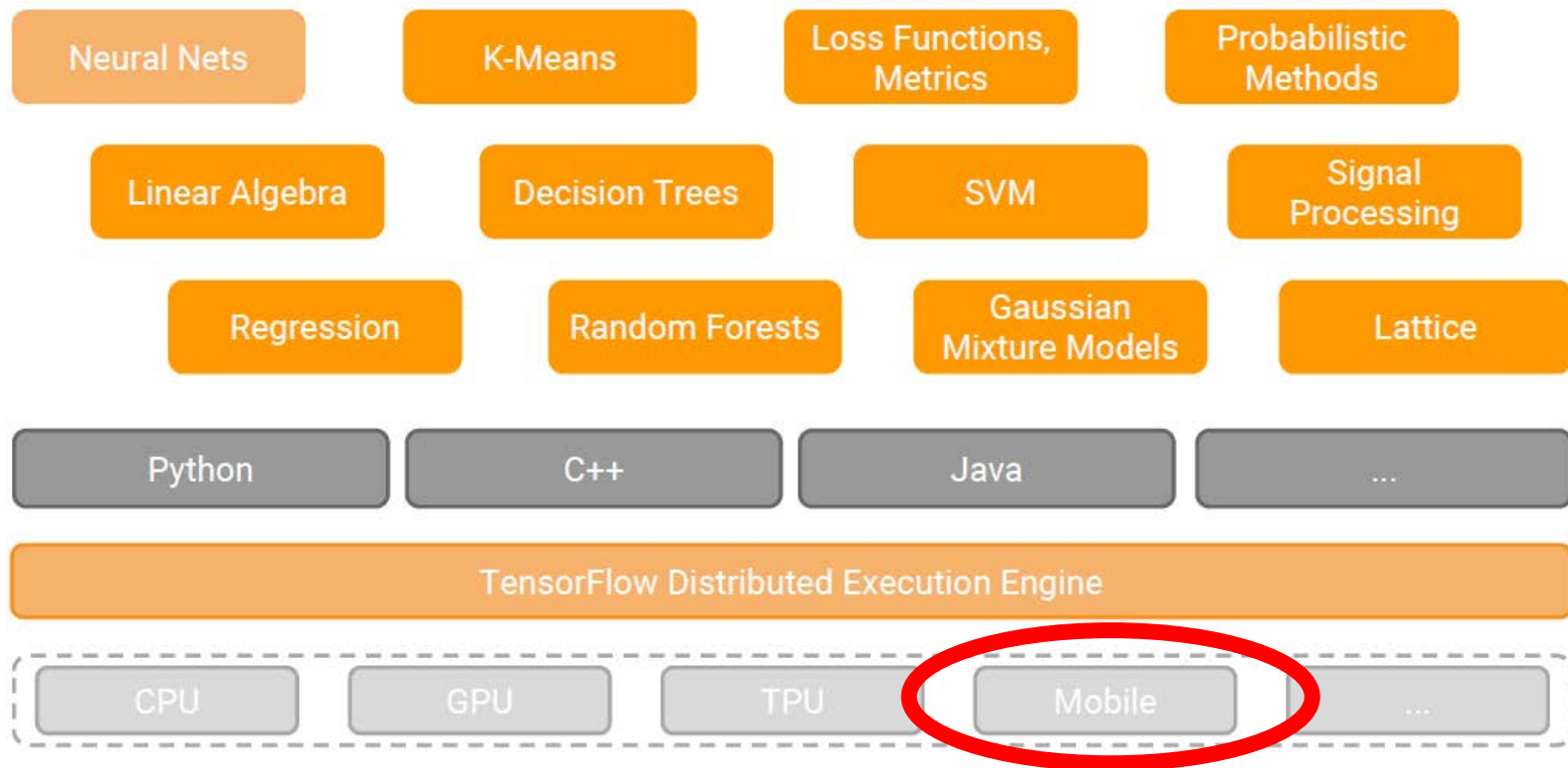


Label: Hand, Confidence: 0.930078, EntityID: /m/0k65p, Frame: (0.0, 0.0, 0.0, 0.0) Label: Tie, Confidence: 0.864361, EntityID: /m/01rkbr, Frame: (0.0, 0.0, 0.0, 0.0)

# Trend

Machine Learning  
+  
Mobile (Android)  
=  
Turnkey Solution

## A comprehensive ML toolkit





谢谢

