Low-Cost Deep learning Trained Cloud-IoT-Edge System For Predicting Banned Items With Accuracy

Dr. Rajiv Misra
Professor
Dept. Of CSE, IIT PATNA

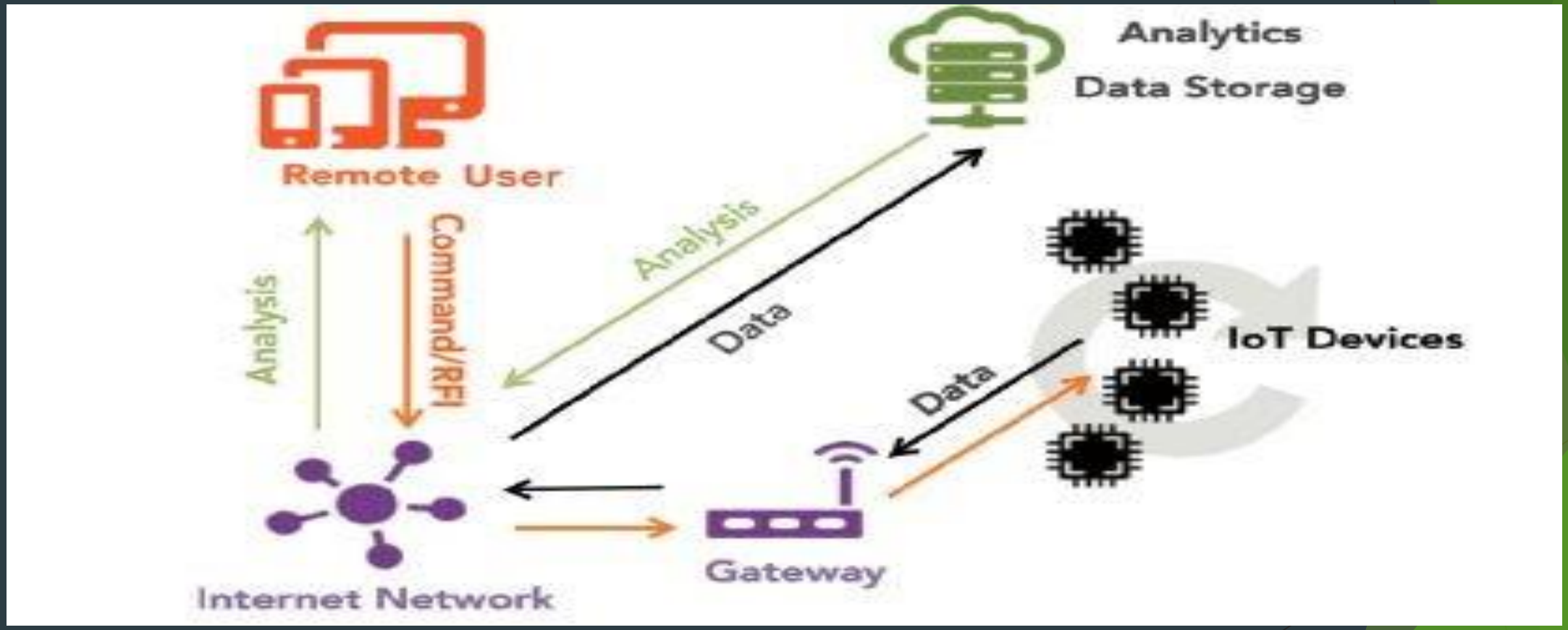
Outline

- Introduction of IoT Edge Computing
- Edge Machine Learning
- Problem Statement and Related Work
- Proposed System Design
- Experiment Setup, Results and Discussion
- Conclusion and future work
- References

IOT Edge Computing

- The amount of data generated by sensors, actuators,and other devices in the Internet of Things (IoT) has substantially increased in the last few years
- As a consequence, network bandwidth and communication latency become serious bottlenecks
- To help address these issues, the concept of *edge* computing has been proposed
- According to this paradigm, computing resources are made available at the edge of the network, close to (or even co-located with)end-devices

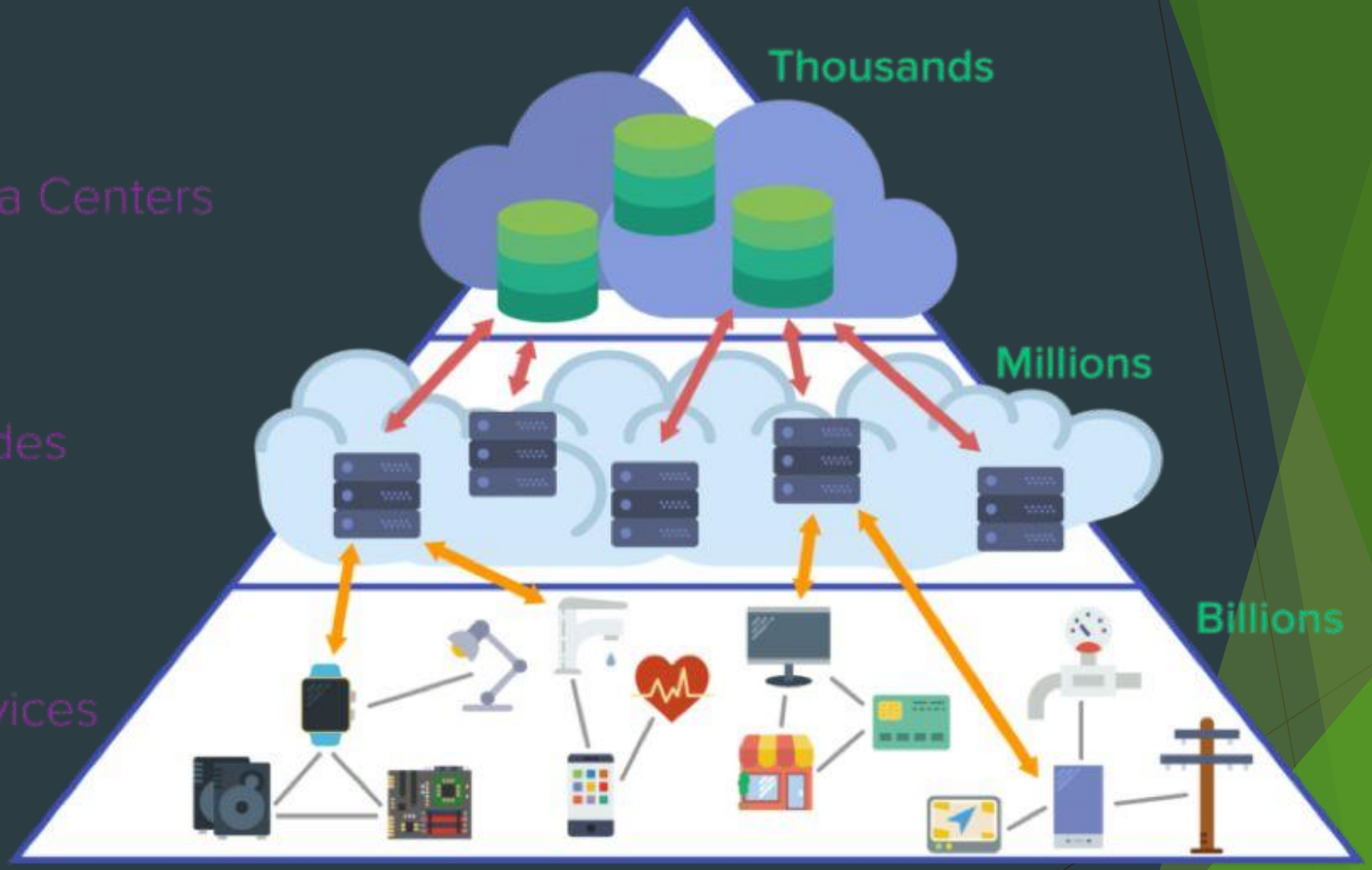
IoT Computation



CLOUD | Data Centers

FOG | Nodes

EDGE | Devices



Device Categories

Challenges

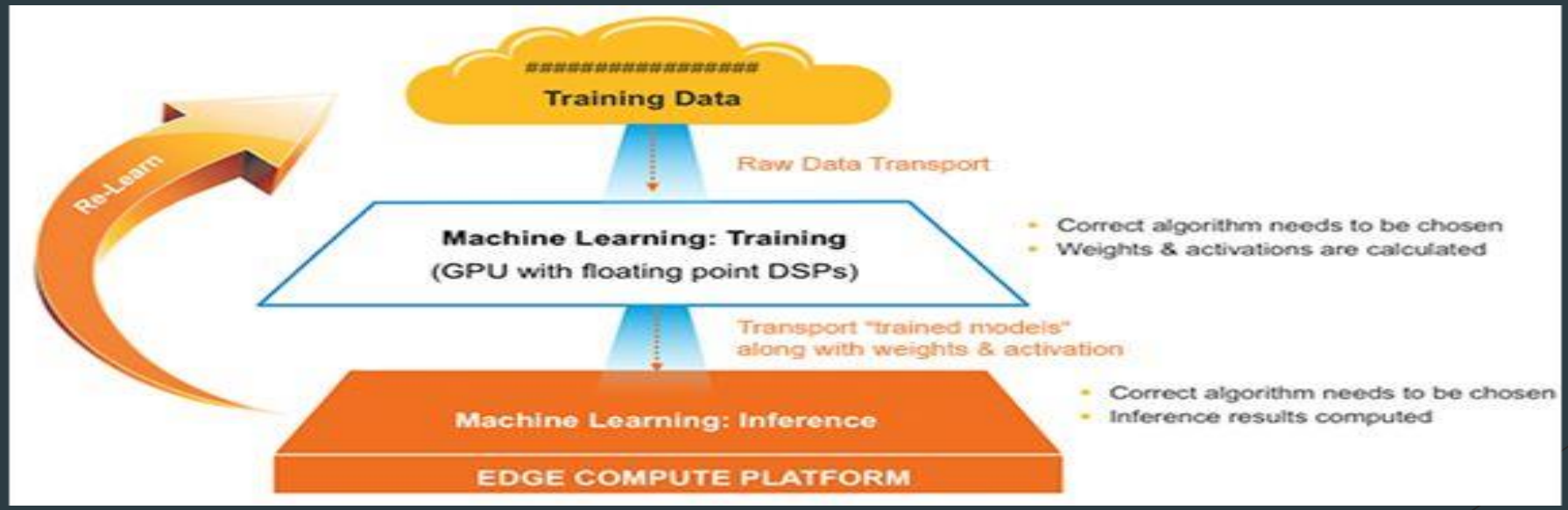
- IoT is covering an ever-increasing range of applications, such as healthcare monitoring, smart home, smart building, smart city, smart industry etc
- One of the challenges in IoT is to process and analyze a huge amount of data from heterogeneous devices
- **Limited Resources on the Edge of IoT system**
  - Processing Capability Constraint
  - Bandwidth Constraint

How do We make IoT Environment Intelligent?

- The application of AI technologies such as machine and deep learning algorithms, computer vision, natural language processing(NLP), video processing etc. has provided the driving force behind the realization of smarter systems, services and solutions.
- IoT Data analytics at the edge and the cloud levels is the prominent and dominant aspect for knowledge discovery and dissemination.
- Concept of Smart contracts using Blockchain leads to sophisticated and decentralized applications.

Edge ML/DL

- A new paradigm where *even tiny,* ***resource-constrained IoT devices can run machine learning algorithms locally*** without necessarily connecting to the cloud



Problem Statement

- How to make a Low Cost Edge device Intelligent by Deploying AI capabilities on them and make latency sensitive application achievable?

Related Work

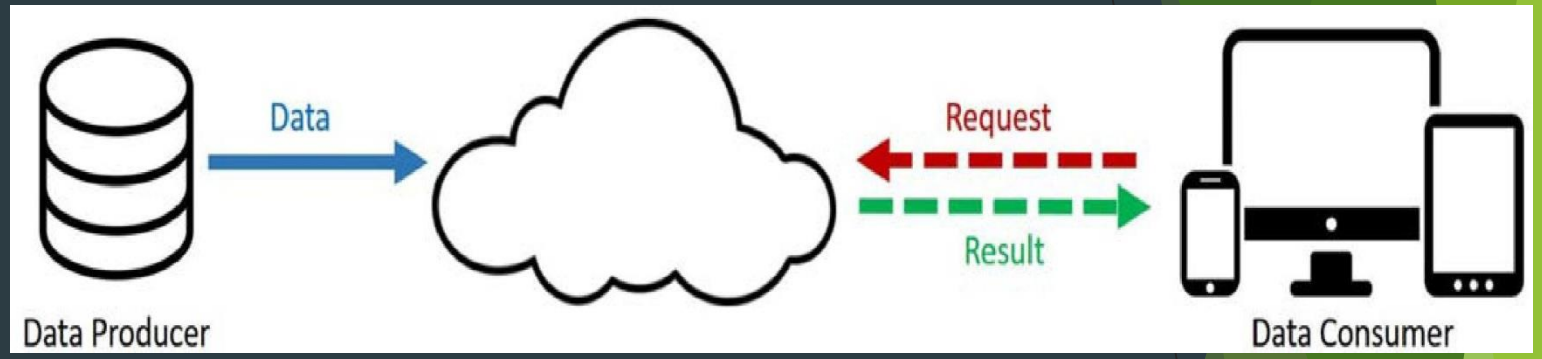
- Current State of the Art
  - Transfer data to the “cloud”. Perform data analytics using a parallel computing framework[1]

Why Not Cloud for IoT Data analytics???

- Latency and Response time
- Security and Privacy
- Offline usages
- Bandwidth cost and power consumption
- Real time data capture, storage, processing

Why do we need Edge Computing?

- Push from cloud services
- Pull from IoT
- Change from Data Consumer to Producer

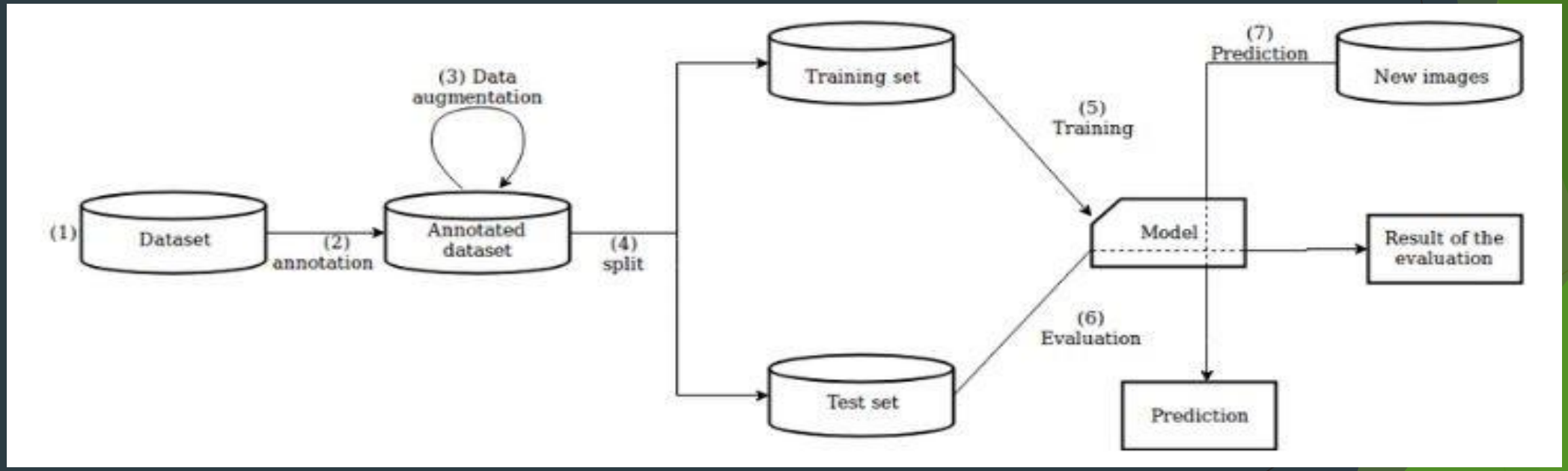


Related Work Continued…

- A new design of CloudEdge Collaboration Framework for IoT data analytics which helped optimize network performance and protect user privacy in uploading data[2].

Object Detection

Object Detection Workflow



Deep Learning Based Object Detection

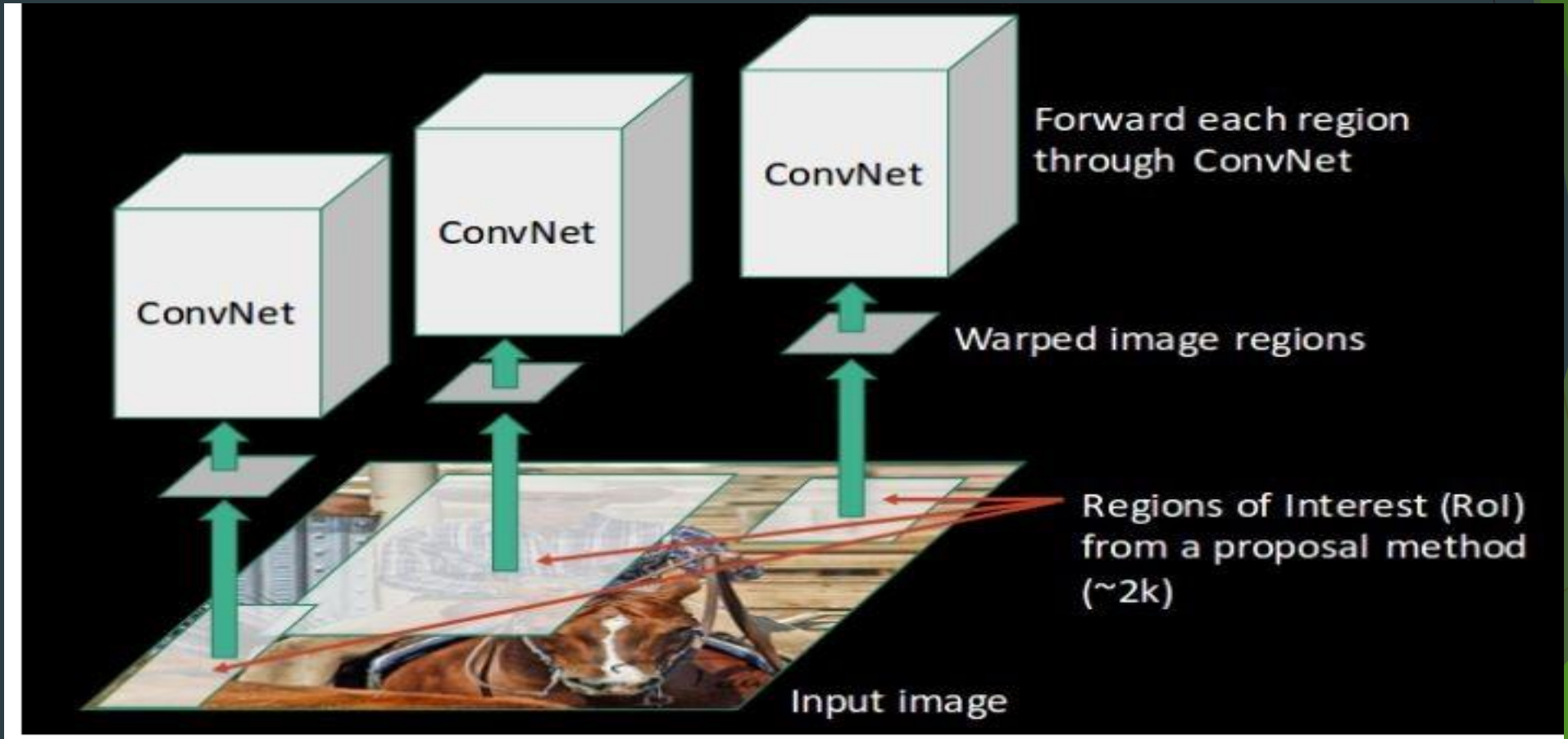
- Why Not CNN?
- RCNN
- Faster RCNN

RCNN

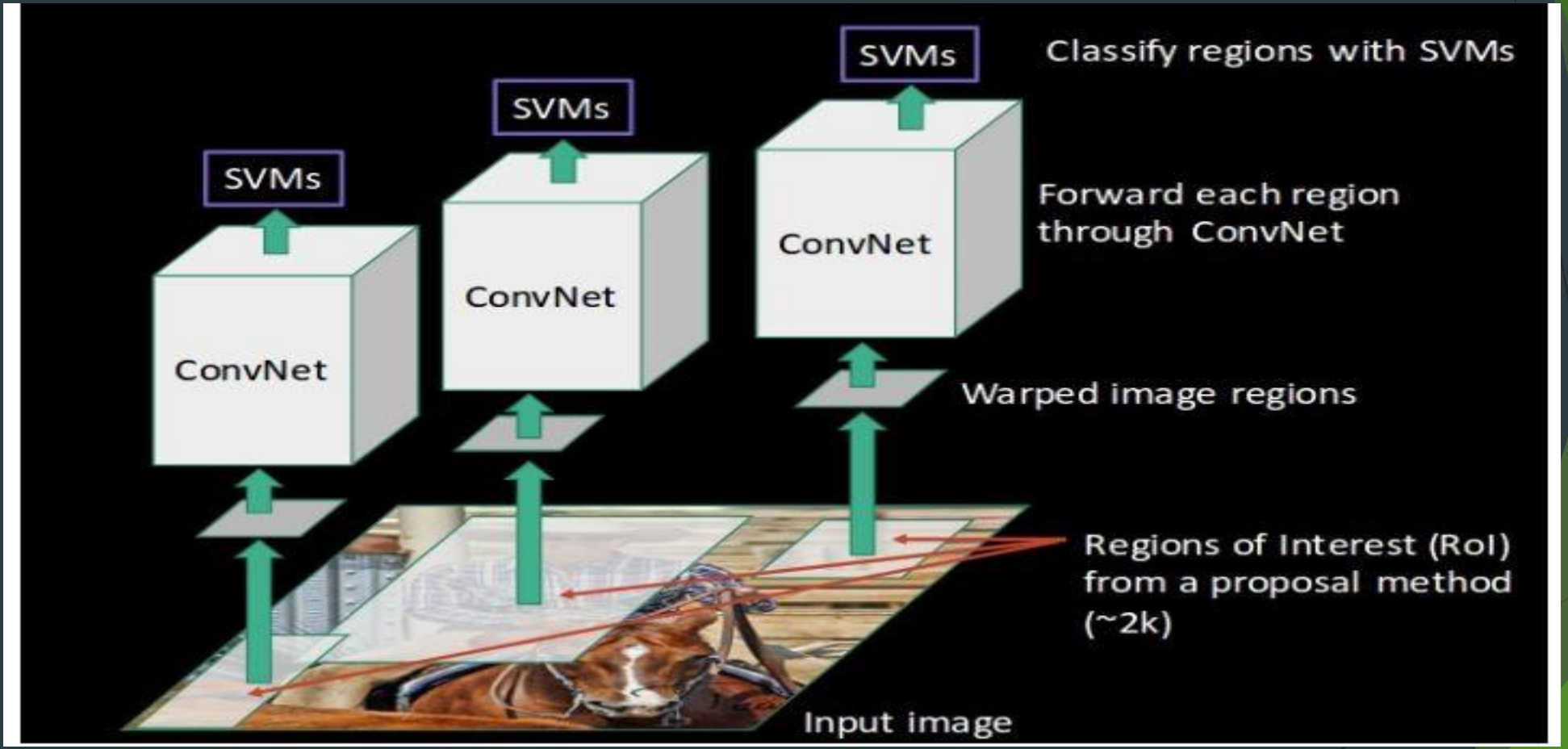
An image is taken as an input

Then, we get the Regions of Interest (ROI) using some proposal method (for example, selective search)

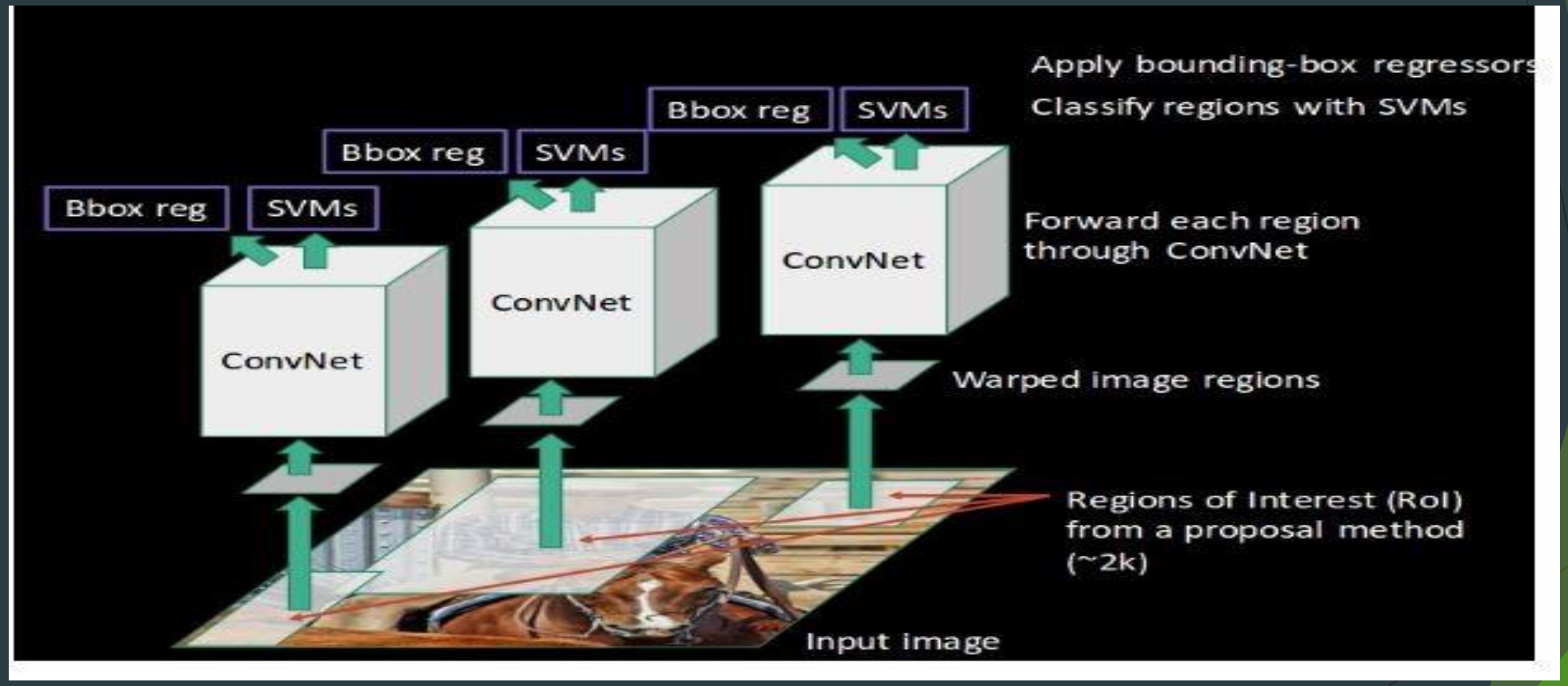
All these regions are then reshaped as per the input of the CNN, and each region is passed to the Conv Net

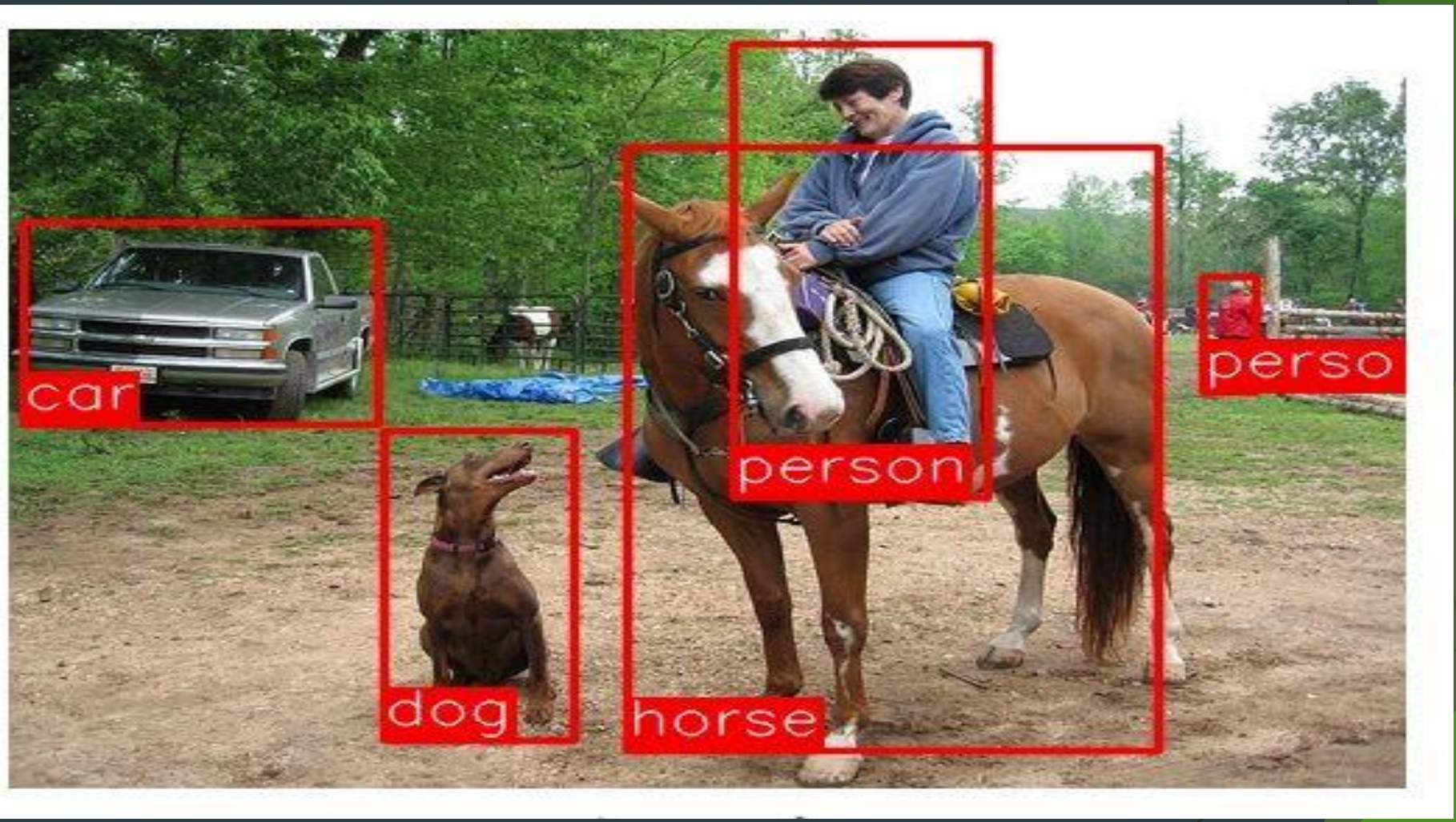


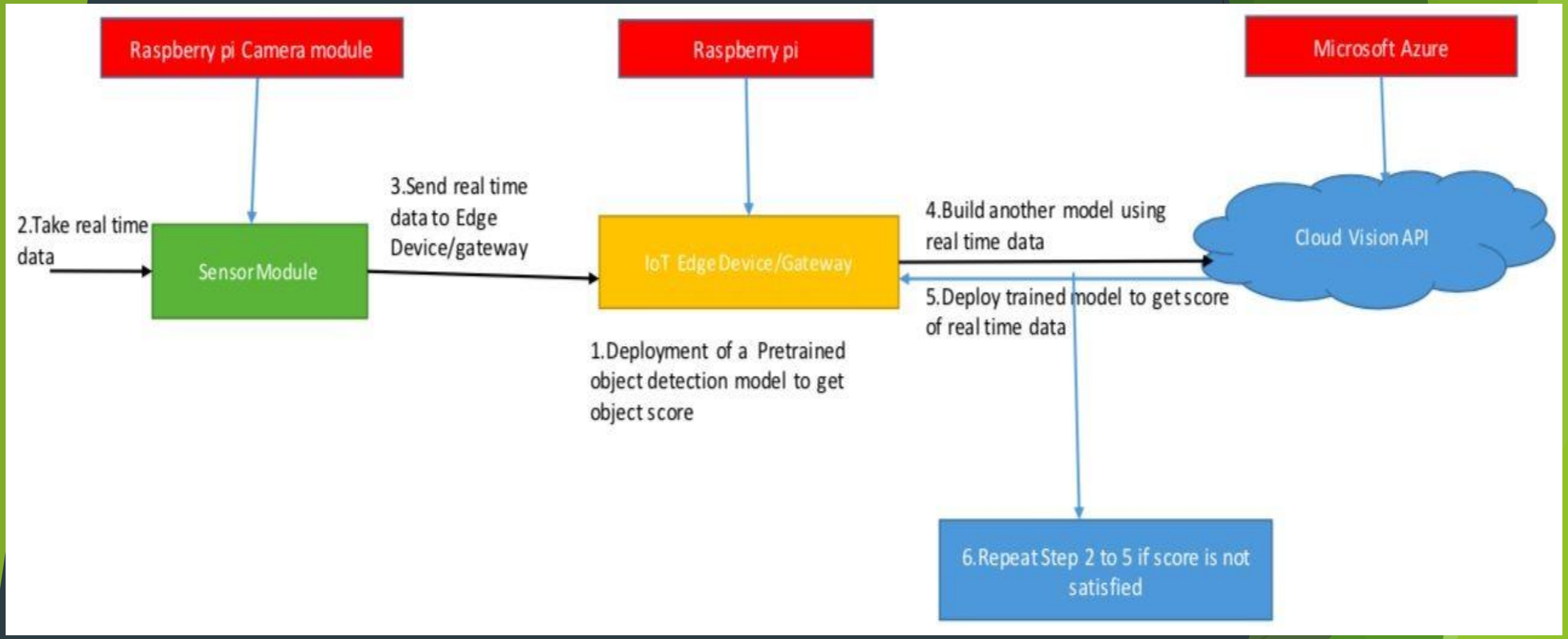
CNN then extracts features for each region and SVMs are used to divide these regions into different classes



Finally, a bounding box regression is used to predict the bounding boxes for each identified region:

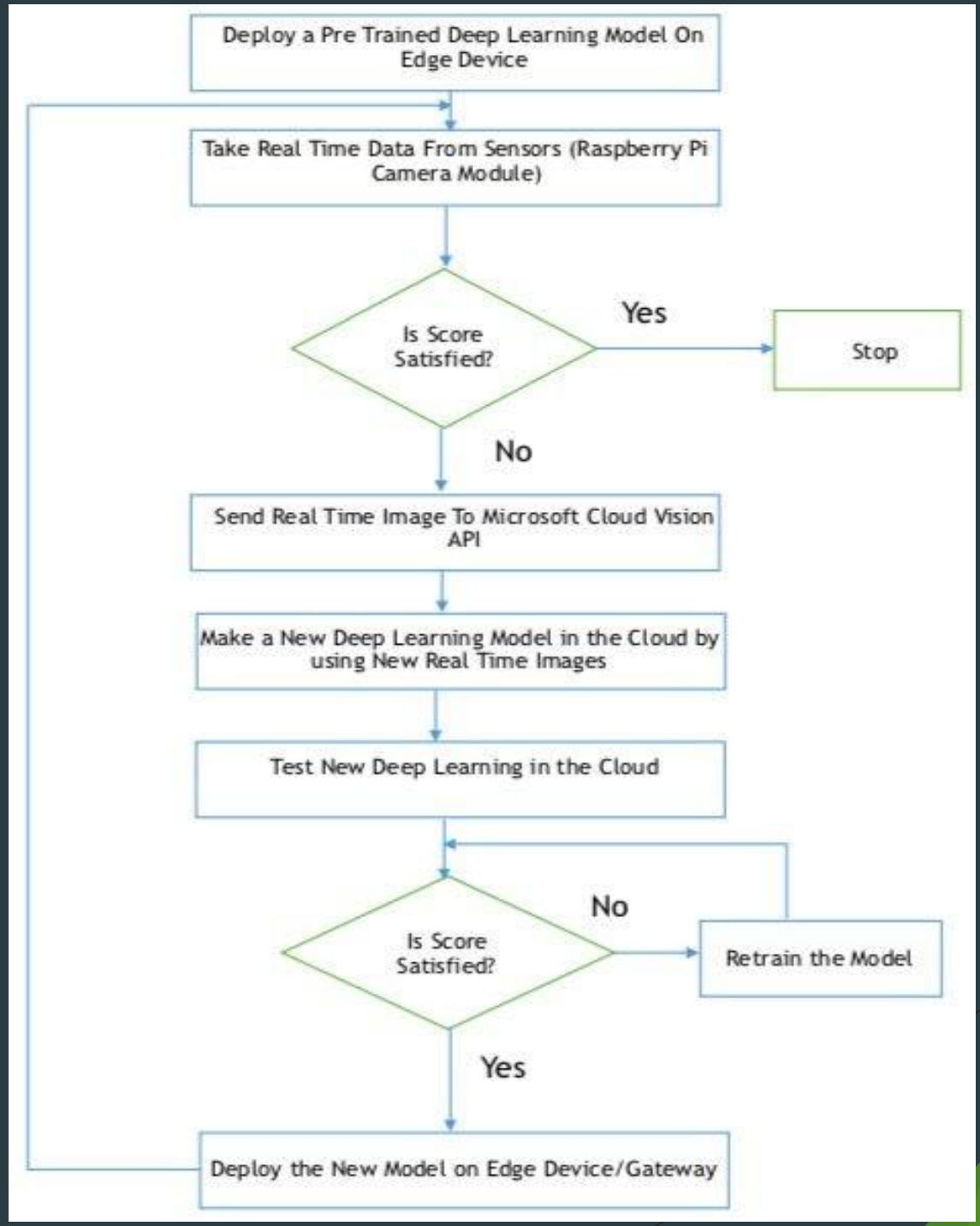



car
dog
person
horse
perso



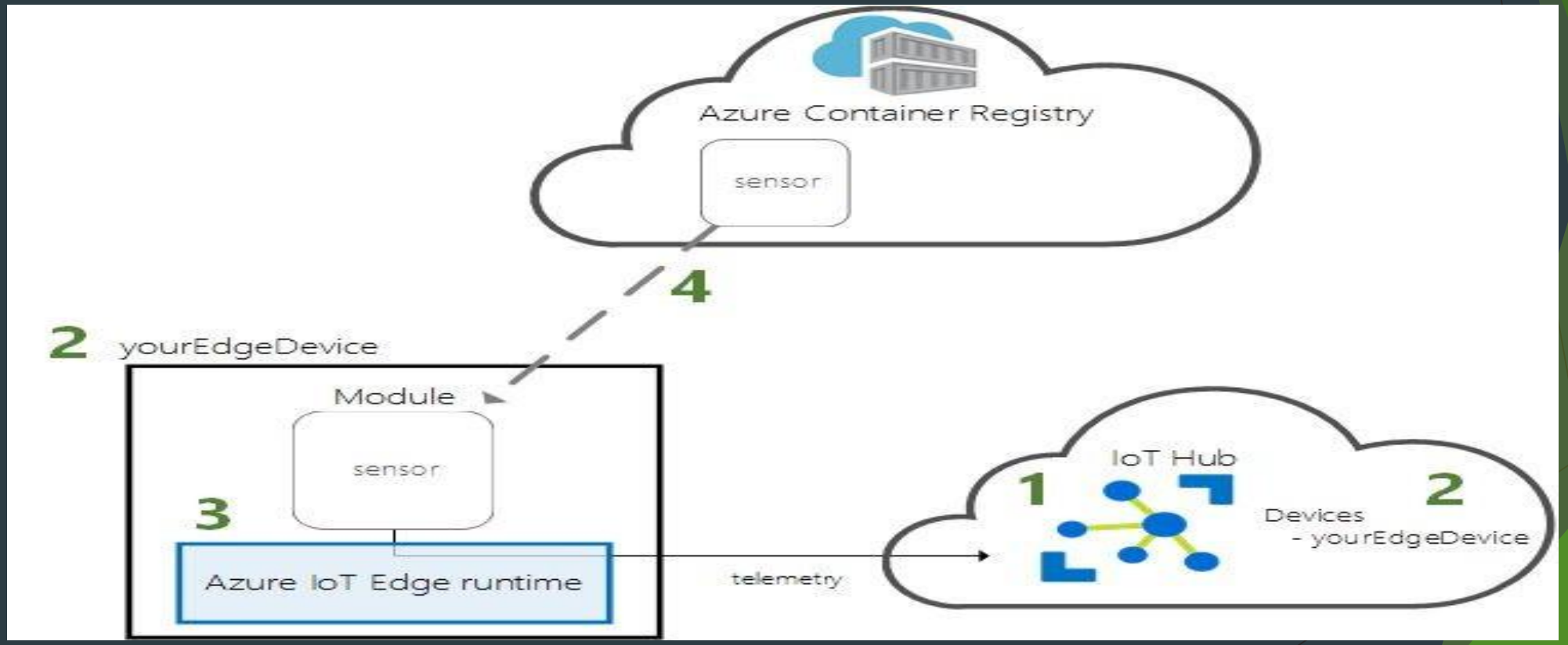
Our Proposed System Design

Flow Chart


Deploy a Pre Trained Deep Learning Model On Edge Device
Take Real Time Data From Sensors (Raspberry Pi Camera Module)
Is Score Satisfied?
Yes
Stop
No
Send Real Time Image To Microsoft Cloud Vision API
Make a New Deep Learning Model in the Cloud by using New Real Time Images
Test New Deep Learning in the Cloud
Is Score Satisfied?
No
Retrain the Model
Yes
Deploy the New Model on Edge Device/Gateway

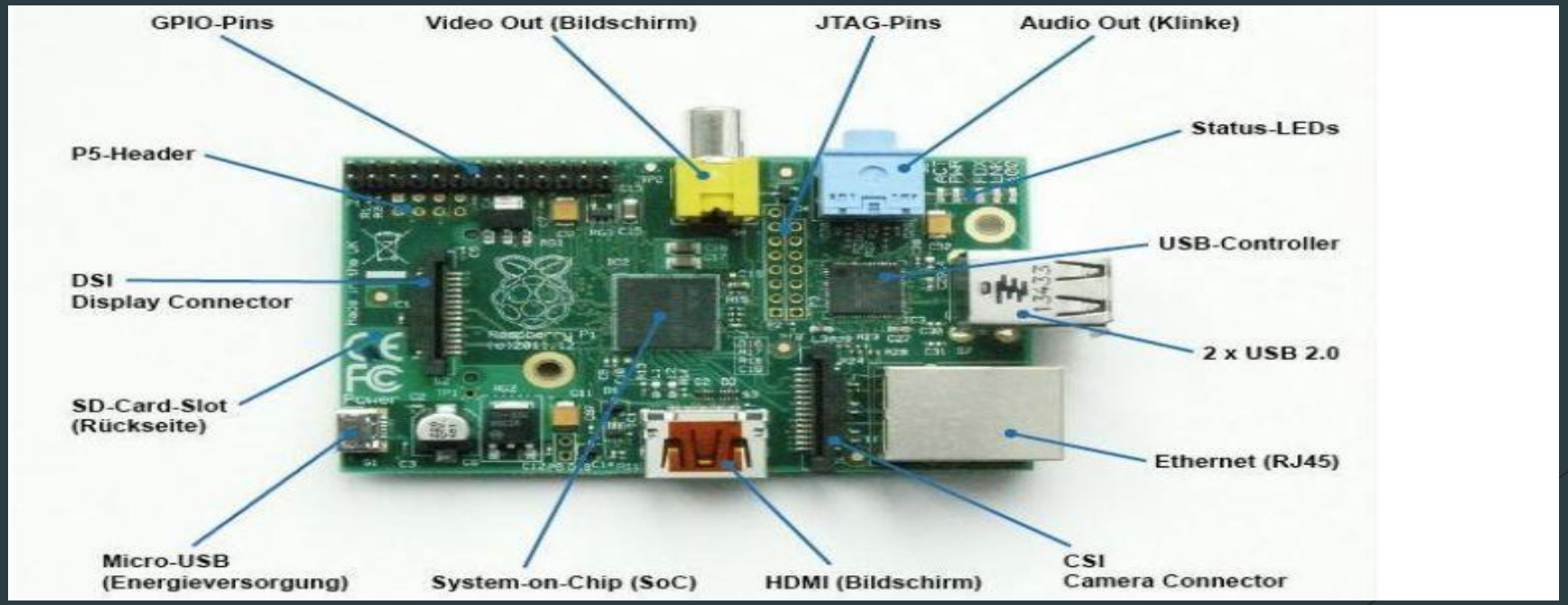
Experiment Set Up

- Edge Computing Platform used:-
  - Azure IoT Edge



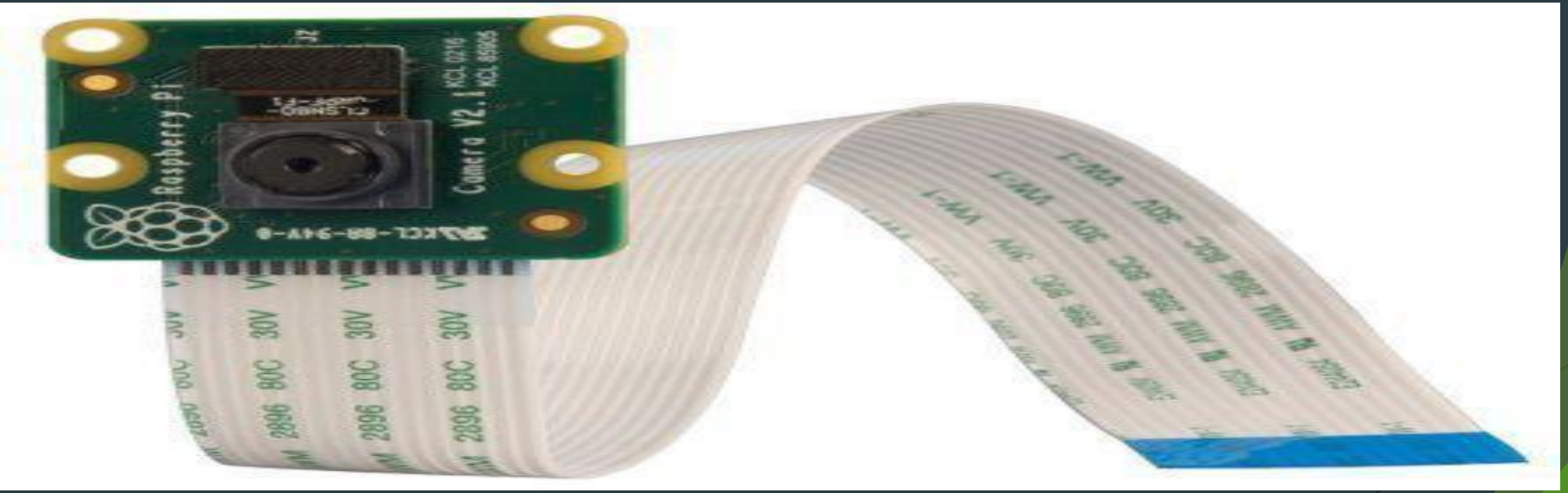
Continued..

- Hardware used:-
- **Raspberry Pi 3 Model B+**



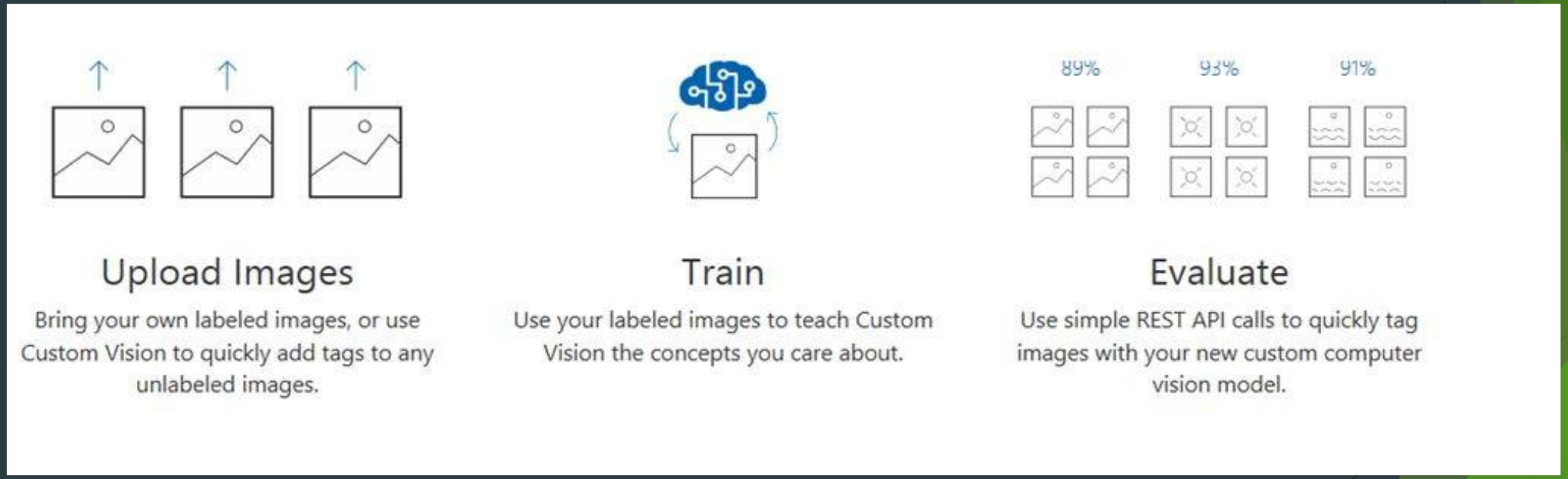
Continued….

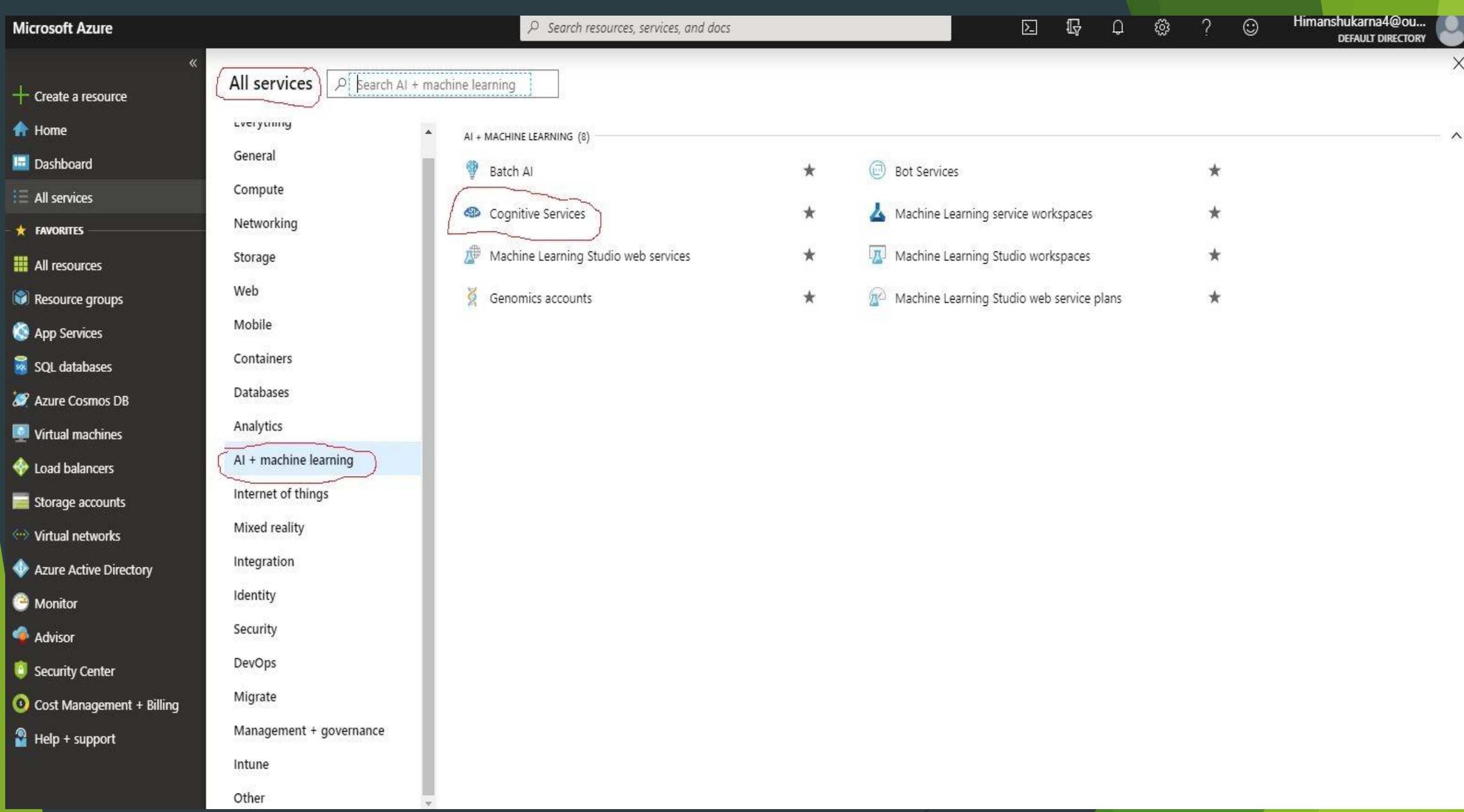
- Sensor Used:-
- Raspberry pi Camera Module



Continued:-

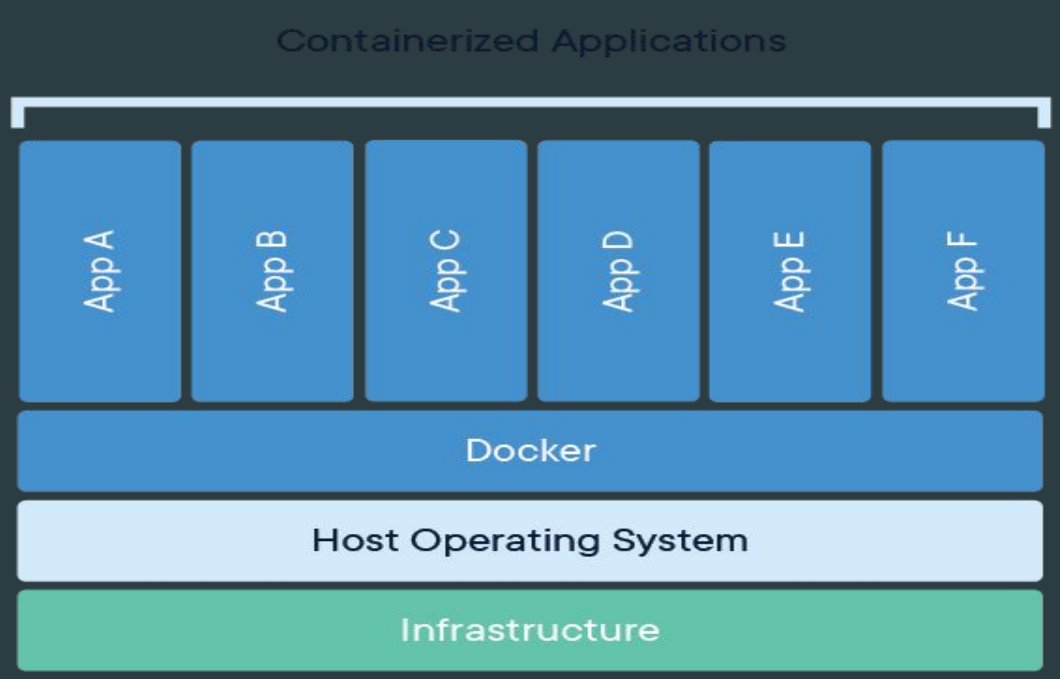
- Cloud Computing Platform used for Machine learning:-
- Microsoft Vision API

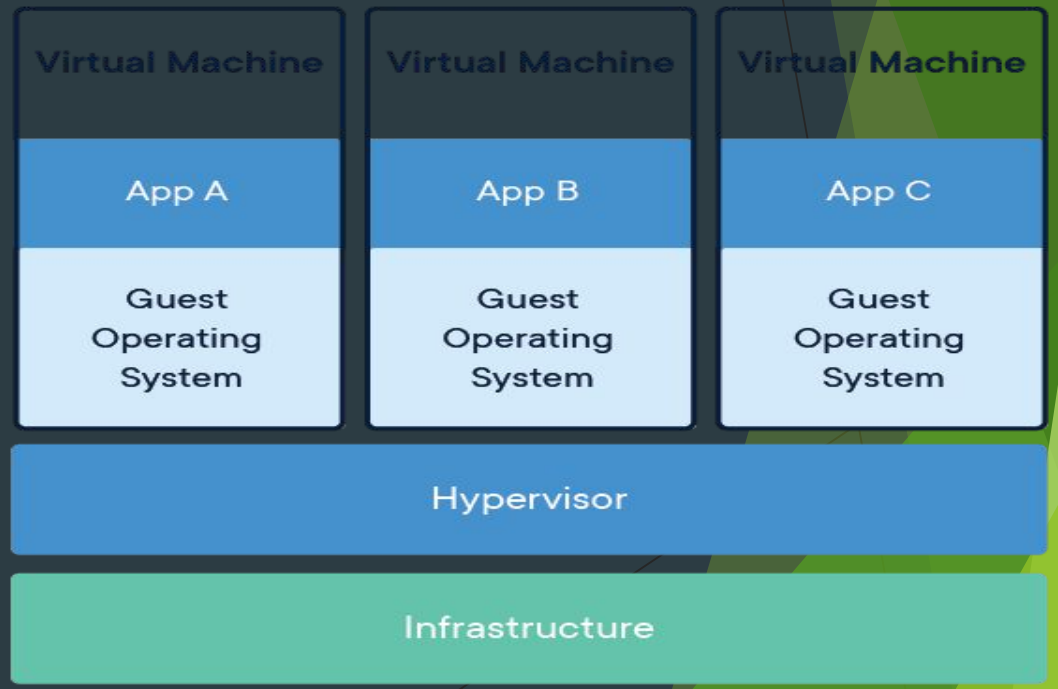



Microsoft Azure
Search resources, services, and docs
Himanshukarna4@ou...
DEFAULT DIRECTORY
Create a resource
Home
Dashboard
All services
FAVORITES
All resources
Resource groups
App Services
SQL databases
Azure Cosmos DB
Virtual machines
Load balancers
Storage accounts
Virtual networks
Azure Active Directory
Monitor
Advisor
Security Center
Cost Management + Billing
Help + support
All services
Search AI + machine learning
General
Compute
Networking
Storage
Web
Mobile
Containers
Databases
Analytics
AI + machine learning
Internet of things
Mixed reality
Integration
Identity
Security
DevOps
Migrate
Management + governance
Intune
Other
AI + MACHINE LEARNING (8)
Batch AI
Bot Services
Cognitive Services
Machine Learning service workspaces
Machine Learning Studio web services
Machine Learning Studio workspaces
Genomics accounts
Machine Learning Studio web service plans

Continued…..

- Software used For Deployment of machine learning from Cloud to Edge Device:-
- Docker

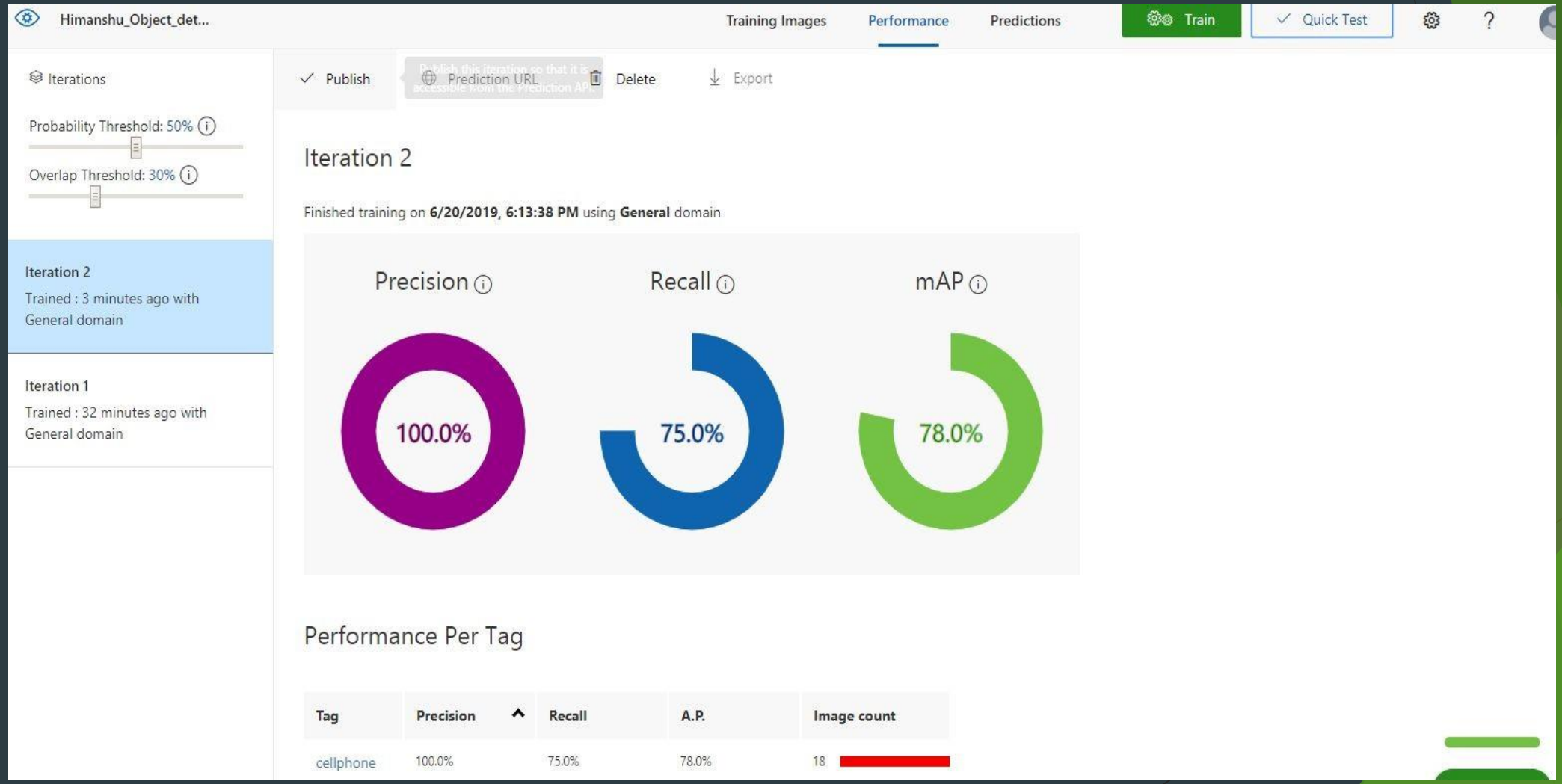




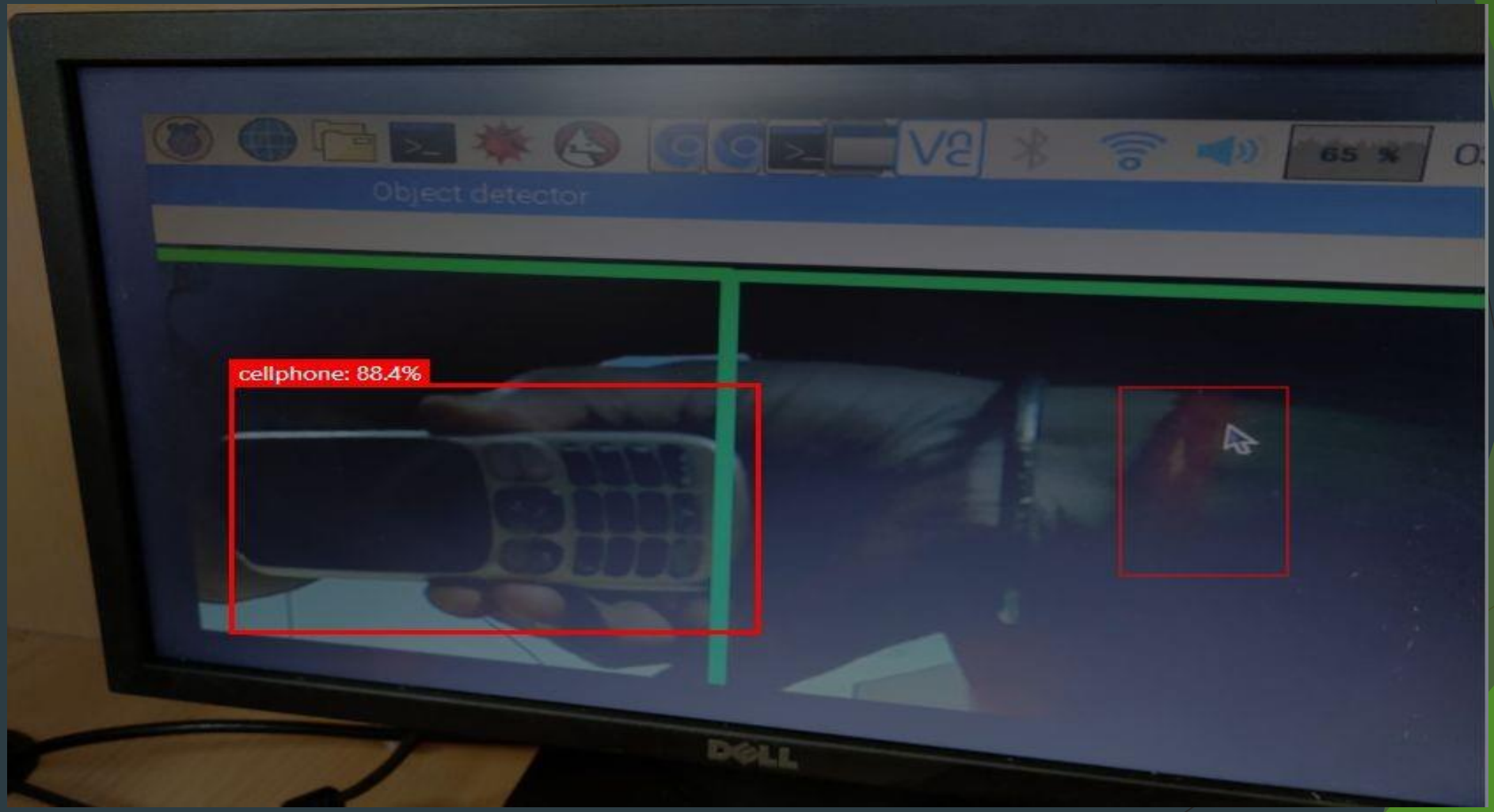
Continued…..

- Other Software Used:-
  - Advanced IP Scanner
  - PUTTY
  - VNC viewer
- Machine Learning Algorithm Used:-
  - CNN
  - RNN
- Framework/Library Used:-
  - Tensor flow
  - Open CV
- Data Set Used:-
  - COCO dataset

Results


Himanshu_Object_det...
Training Images
Performance
Predictions
Train
Quick Test
Iterations
Probability Threshold: 50%
Overlap Threshold: 30%
Iteration 2
Trained : 3 minutes ago with General domain
Iteration 1
Trained : 32 minutes ago with General domain
Publish
Prediction URL
Delete
Export
Iteration 2
Finished training on 6/20/2019, 6:13:38 PM using General domain
Precision
Recall
mAP
100.0%
75.0%
78.0%
Performance Per Tag
Tag
Precision
Recall
A.P.
Image count
cellphone
100.0%
75.0%
78.0%
18

Continued….



Conclusion and future work

- We have deployed a trained model on low cost Edge Device i.e. Raspberry pi and run an object detection model on that, and if model accuracy is not desirable we built another model on cloud, retrained it and after getting the desired accuracy we deployed it on raspberry pi.

- Future Work can be on building a more smarter and intelligent edge device by incorporating reinforcement learning at the Edge.

- Another Future Work can be to Build a low cost Distributed Cluster of Edge Device and thereby saving cost and time for the user.

References

- Xu B, Mylaraswamy D, Dietrich P. A cloud computing framework with machine learning algorithms for industrial applications. InProceedings on the International Conference on Artificial Intelligence (ICAI) 2013 (p. 1). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).Yuyi Mao and Jun Zhang. Dynamic computation offloading for mobile-edge computing with energy harvesting devices. IEEE Journal of Solid-State Circuits, 51(3):712–723, 2016.

- Moon, Jaewon, et al. "Cloud-Edge Collaboration Framework for IoT data analytics." *2018 International Conference on Information and Communication Technology Convergence (ICTC)*. IEEE, 2018.