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# Fruit Eye Link

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**Group Name:** BlowYourHat

In 2019, 1 in 3 people reported not consuming any fruit or vegetable daily



Only 12% of the population reached the recommended daily consumption



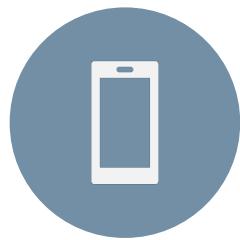
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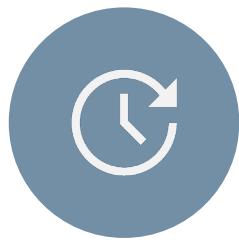
BUSINESS  
ASPECTS



ETHICAL  
PERSPECTIVES



TECHNOLOGICAL  
SOLUTION



FUTURE  
DIRECTION



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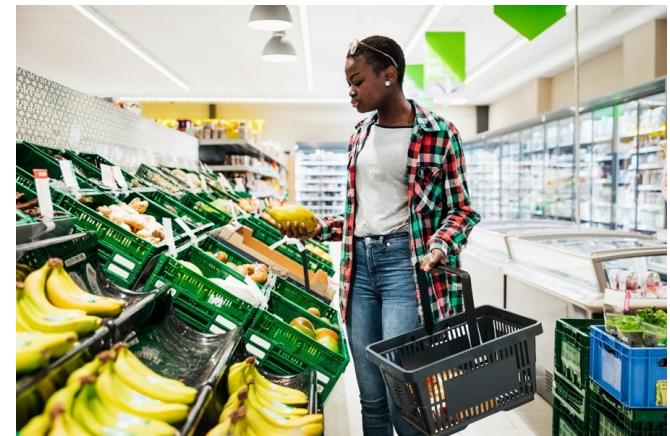
# Business

Market and values

# What the current experience?

- Customers ***need to weight the items*** to buy them.
- Customers need to ***know the item number or the name***

Enhancing customer experience by improving the way they buy fruits, by an ***intelligent scale!***

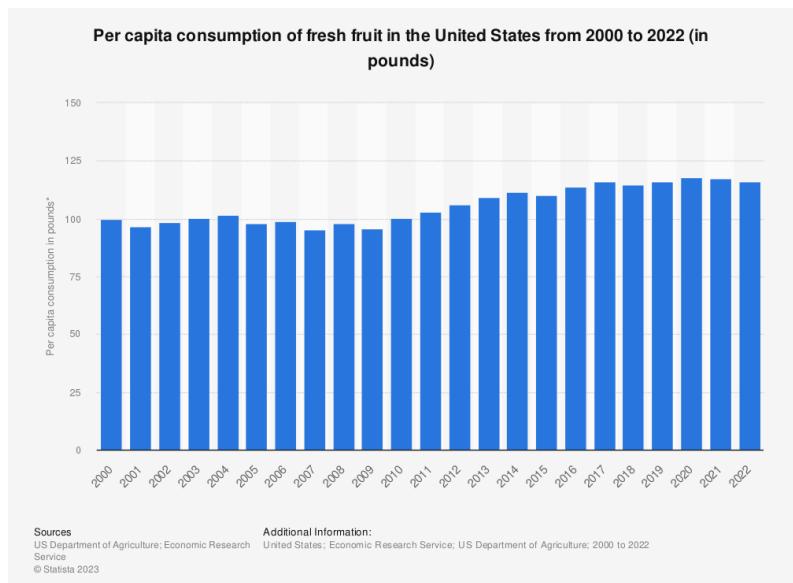


# A market perspective

The ***fresh products*** department is the main determinants among consumers when selecting a grocery store

- ***New interests*** in healthy diet!
- ***New automatized stores***  
(e.g. belgian supermarket)

***Customer satisfaction plays a huge role in market sales!***



# Our target costumer

We will empower the retail sector by putting **more control** on the sales.

- We are doing this ***by improving customer experience***

Our customer are:

- Big supermarkets
- Fruits stores



# Our solution

- Based on a *list of fresh products*.
- Customer interacts with the scale *to print the label*.
- *Customer selects* the predicted category.

The portion of fruit must be inside a bag or loose, so that the camera can see the content



# Business - Values

- ***Customer Orientation***: The customer is at the center of every decision.
- ***Sustainability***: A commitment to sustainable business practices.
- ***Innovation***: The adoption of new technologies and processes to improve operational efficiency and customer experience.



# Customer Orientation

Putting customer needs at the heart of the business you ***increase profit.***

- The removed repetitive tasks leave space for imagination and inspiration.
- Workers have an increased commitment to the public.



# Sustainability

- Efficient ***use of energy***
- Sustainable packaging are now fully sustainable without sticky labels
- ***Reducing food waste*** with more sales of fruit and vegetables



# Innovation

- Old scales ***cause issues to customers and cashiers.***
- Added value and ***customer loyalty.***
- More technological stores attracts ***new categories of customers***



Author: Panuwat Dangsungnoen | Acknowledgments: 123RF  
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# Ethical Review

Privacy, inclusivity and user well-being

# Ethical Aspects

Engineering design has been regarded as a form of materializing morality.

- Privacy
- Inclusivity
- Job displacement
- Good care and user well-being

# Privacy

Our solution works on images given by the user.

- The camera is oriented to ***only capture the plate***
- Data and decision are ***on-device***
- ***No flow of data*** on the internet

Who owns the data?



# Inclusivity

- Digital **technology needs to be human-related**
- **Ease of use**, by multi-modality

We need to be able to work with users from **different contexts**

- **No need to look** at the labels attached to shelves
- “**speaking**” calculator



# Job Displacement

- Automation gives to workers the ***chance to center in the real tasks!***
- Collaboration between workers and the machines.
- Need of guidelines for workers



**JOB DISPLACEMENT**

# Good care and user well-being

- ***Final decision*** will be taken ***by the customer***
- Reduction of repetitive tasks leaves space to inspiration
- Increase ***customer experience***
- Transform industry: collaboration between stakeholders, proactive policies and measures can be implemented, aiming to ensure an inclusive transition to new work models.



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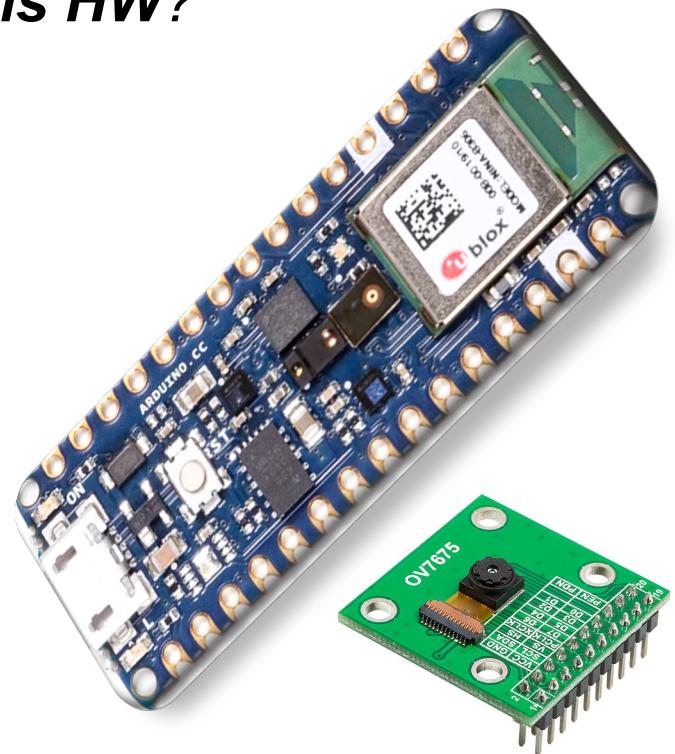
# Technical Aspects

# Hardware Capabilities

Initial study: **What can be done with this HW?**

- *Memory constraints?*
- *Image acquisition pipeline?*

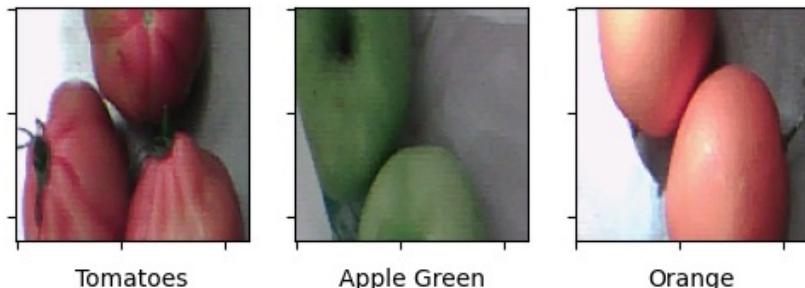
- **RGB565 vs RGB888 (2B vs 3B)**
- Total Image size(**QCIF**, **QQVGA**)
- Total *memory/frame* ?



# Receptive Field and Pre-processing

The camera doesn't have a big *Field-of-View*:

- More than one-meter to contain the entire fruit.
- **Cropping** vs **Resizing** the input.
- Transform to **RGB888**



Samples taken with OV7675

Pre-processing step on the input image

```
// Convert RGB565 (16-bits) to RGB888 (24-bits)
uint8_t baseRed = (pixelCombined & 0xF800) >> 11;
uint8_t baseGreen = (pixelCombined & 0x07E0) >> 5;
uint8_t baseBlue = (pixelCombined & 0x001F);

uint8_t red = (baseRed << 3) | (baseRed >> 2);
uint8_t green = (baseGreen << 2) | (baseGreen >> 4);
uint8_t blue = (baseBlue << 3) | (baseBlue >> 2);
```

# Datasets

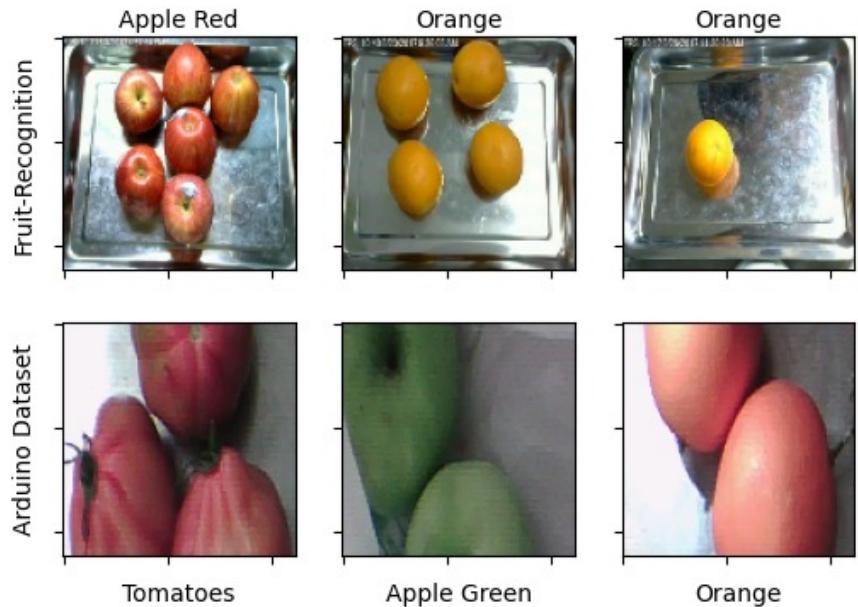
We worked on two datasets

- *Fruit-Recognition dataset* (from Kaggle) -> ~ 7000samples
- Manually acquired ("Arduino dataset") -> 300samples

**Big difference** on image qualities!  
+ The problem of the *FOV*.



Data Augmentation



# Dataset: Data Augmentation

Apart from a common regularization technique, it can be used to "simulate" our real-world data.

- ***ZoomIn*** (heavily used to resemble the reduced FOV)
- ***DegenerateColors*** (to simulate less precision bits)

Random Augmentations

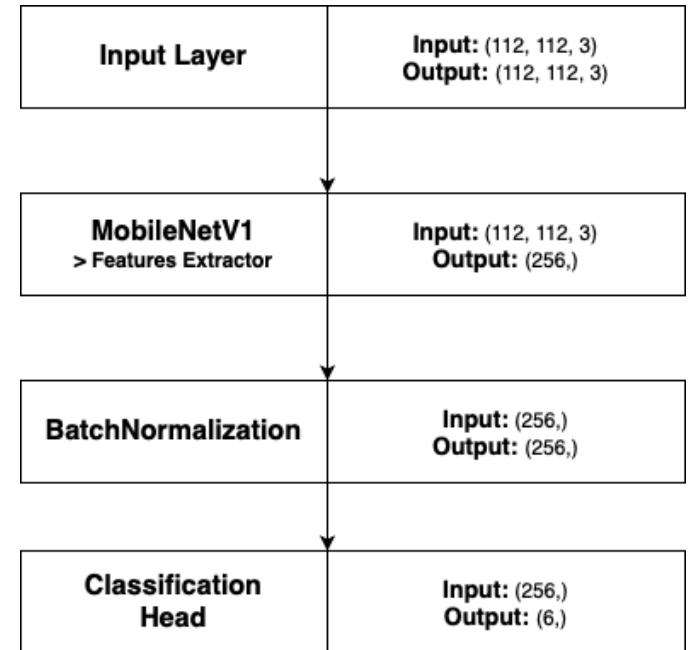


# Models: base model definition

Our base model is a **MobileNetV1** architecture:

- Pre-trained on ImageNet with 96x96 images.
  - Images are in [0..1] range
- 
- + Add a **BatchNormalization Layer**.
  - + A **ClassificationHead (DenseLayer)**.

We use a 112x112  
image input!!



# Models: post-processing

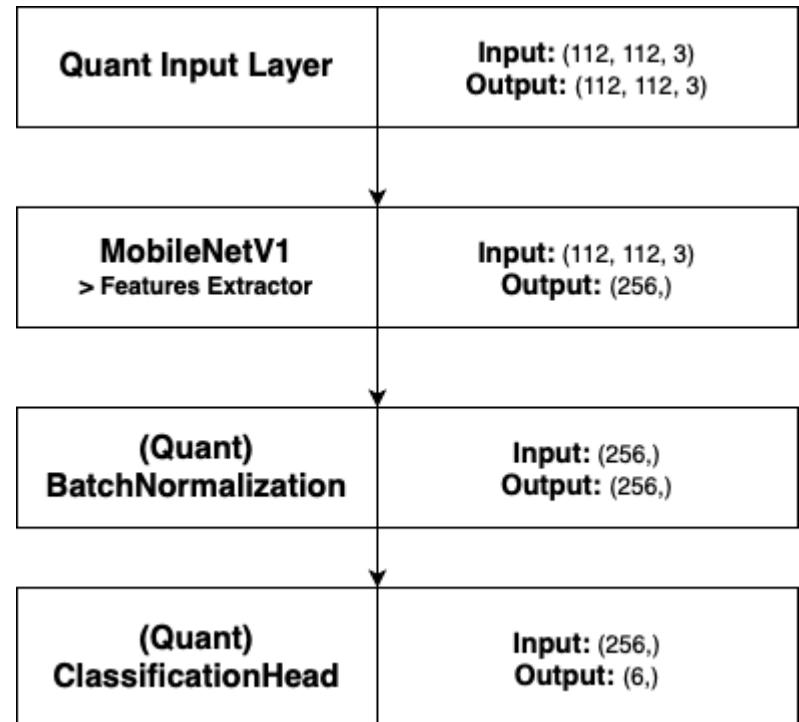
After training the model, we *Quantize* them.

- Dynamic Range (DQR)
- An int with float fallback (Mixed)
- Full-int model (FIQ)

Additionally, we also explored:

- Quantization-Aware Training

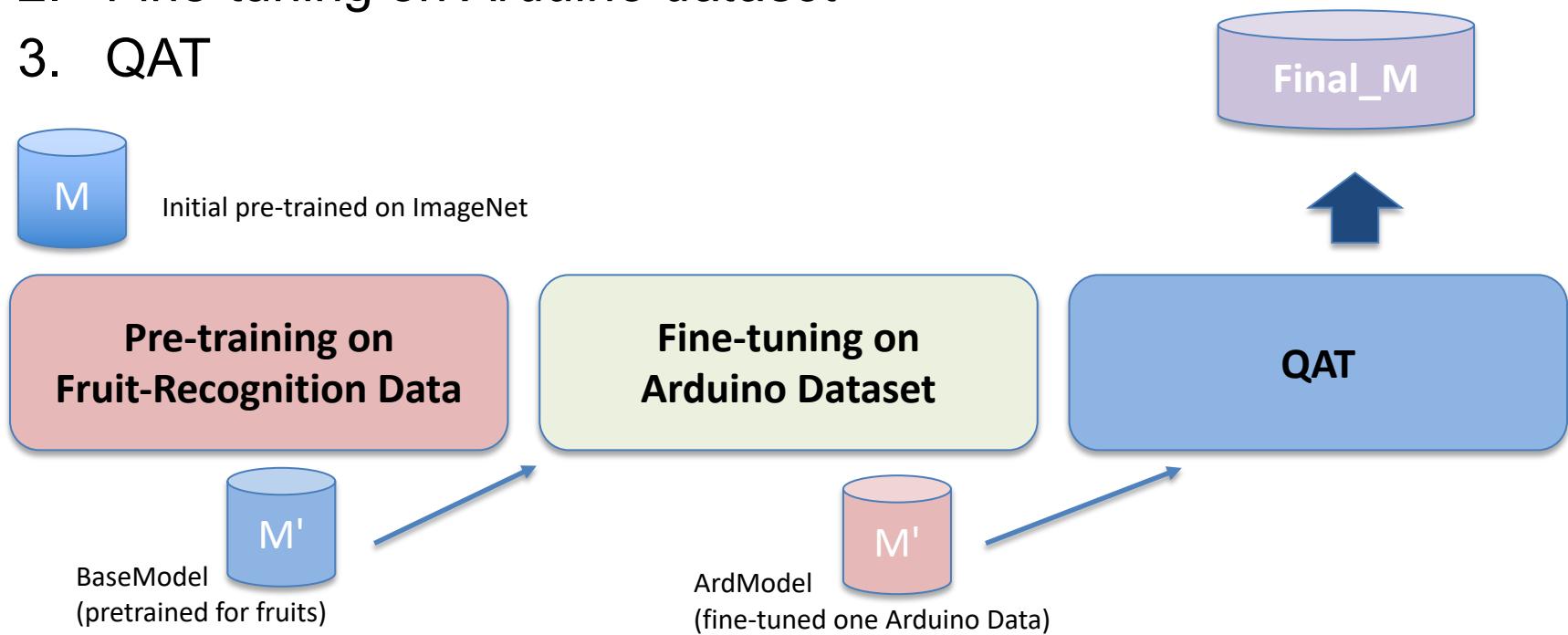
Method	Memory usage	Ralative Speedup
Base Model	2.1MB	x1
Dynamic Range	293KB	x-4.8
Mixed	323KB	x2.4
Full-integer	323KB	x2.1



# Training

The training was **divided in three phases**:

1. Pre-training on *Fruit-recognition dataset*.
2. Fine-tuning on *Arduino dataset*
3. QAT

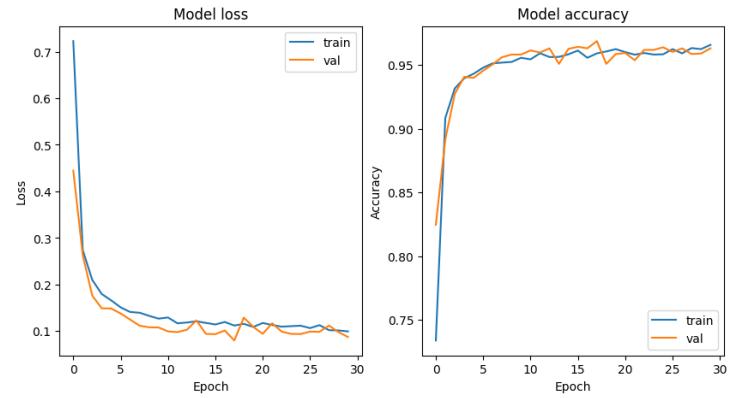
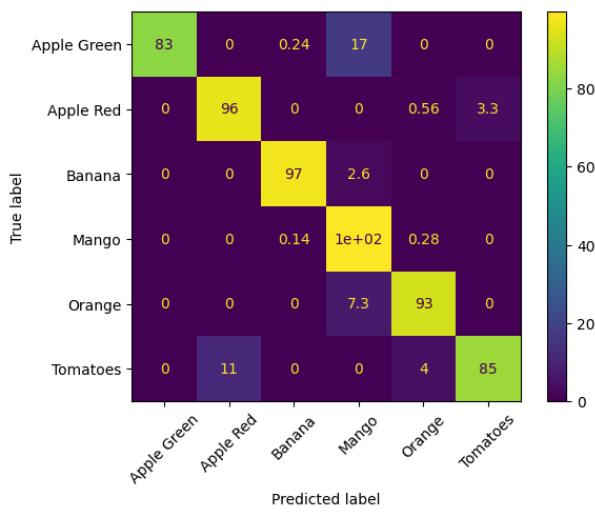
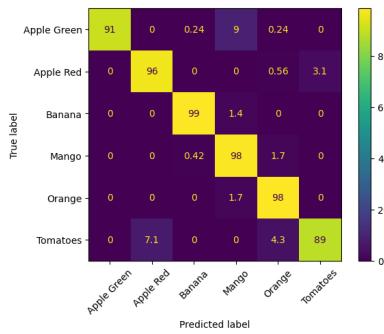


# Results: Pre-training

During pre-training the train data was splitted between training and validation.

- Search number of epochs!

## *Transfer-Learning + Fine-Tuning*



Transfer-learning: 18Eps  
Fine-tuning: 7Eps

# Results: Fine-tuning on Arduino Data

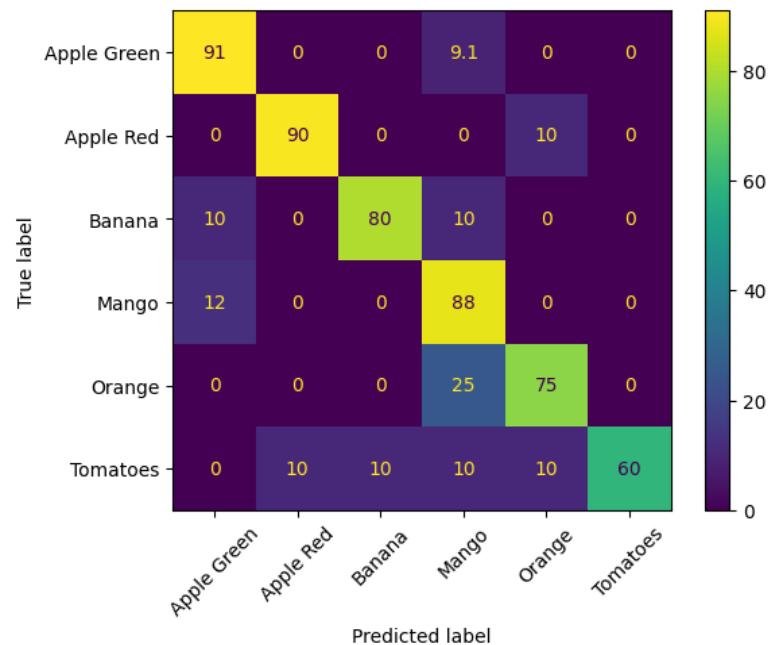
The small dataset, easy to overfit

- **Cross-validation** on the *train* split.
- Final results computed on *test* split.
- Dropout layer during training

*Fine-tuning* here is used on the CNN backbone!

Model	Accuracy	Macro-F1 Score
Arduino Model	0.853	0.849
DRQ	0.820	0.801
Mixed	0.820	0.821
FIQ	0.803	0.810

LR	Weight Decay	Fine-Tuning Epochs	Transfer-Learning Epochs
0.005	0.075	75	15



# Results: QAT

Finally, the trained model is QA-trained.

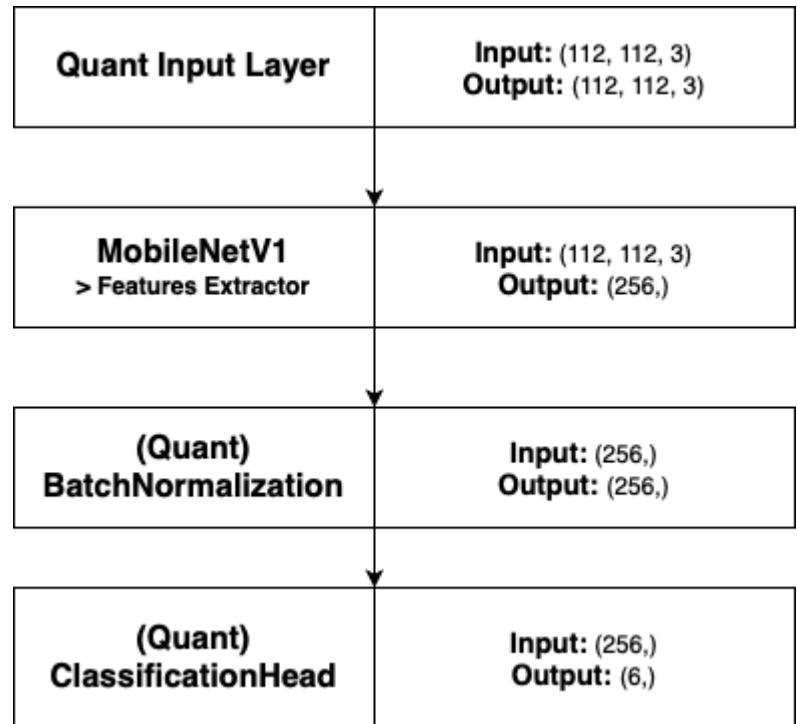
- Very easy to overfit
- Heavy regularisation params.

A lot of tricks to construct the model

- + Big problems

LR	Weight Decay	Training Epochs
1e-4	1.5e-1	16

Model	Accuracy	Macro-F1 Score
QAT Model	0.836	0.814
DRQ	0.836	0.814
Mixed	0.836	0.839
FIQ	0.820	0.829





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# Future Developments

# Acknowledgements

THANK YOU



# Sources

1. what is customer satisfaction [<https://asq.org/quality-resources/customer-satisfaction>]
2. Eurostat - Infographic: Daily consumption of fruit and vegetables in the EU, 2019
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5. Sustainable supermarkets: stop plastic and emissions and save food ([ilfattoalimentare.it](http://ilfattoalimentare.it))
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