

Groupe 5 : Antoine REBOULLET - Arthur CARON

Sujet 3 : Google Home avec IoT ESP32 embarquant de l'IA



Objectif :

Développer un démonstrateur de maison connectée personnalisée utilisant l'assistant Google et de périphérique intelligent à base d'IA sur ESP32

Travail réalisé :

1. nouveau compte google : cpe.demo.iot@gmail.com
2. créer un chatbot de présentation de CPE accessible depuis Google Home
3. inclure dans le chatbot la possibilité d'interagir avec l'ESP32
4. implémenter un réseau de neurone existant dans un ESP32
5. créer notre réseau et l'implémenter dans un ESP32
6. tutoriels et démonstrations vidéo

Technologies :

1. Python, C/C++
2. Google Actions
3. TensorFlow lite
4. Arduino IDE
5. ESP32

Issue board GitLab

The screenshot shows the GitLab interface with the 'Tickets' section selected in the sidebar. There are 12 open issues listed:

Titre	Auteur	Statut	Mise à jour
Vérifier fonctionnement modèle chien/chat	#12 · opened il y a 5 jours by antoine-rb	CLOSED	updated il y a une journée
Implémenter un nouveau réseau sur la carte ESP32	#11 · opened il y a 6 jours by antoine-rb	Doing	updated il y a 6 jours
Renvoyer l'information associée au modèle à l'utilisateur (via MQTT).	#10 · opened il y a une semaine by antoine-rb	Done	CLOSED updated il y a une semaine
Créer notre propre réseau avec nos images	#9 · opened il y a une semaine by antoine-rb	Doing	updated il y a une journée
Intégrer le script cpp (MQTT_ESP32.ino) dans esp-idf	#8 · opened il y a une semaine by arthur caron	CLOSED	updated il y a une journée
Implémenter Tensorflow Lite sur ESP32	#7 · opened il y a 2 semaines by antoine-rb	Done	CLOSED updated il y a 6 jours
Créer app TensorFlow reconnaissance visuelle ou audio	#6 · opened il y a 2 semaines by antoine-rb	CLOSED	updated il y a 6 jours
envoyer une donnée à l'ESP32 via adafruit IO	#5 · opened il y a un mois by arthur caron	Done	CLOSED updated il y a une semaine
envoyer un signal de commande à l'ESP32 via le protocole choisi et allumer la LED (GPIO2?)	#4 · opened il y a un mois by arthur caron	Done	CLOSED updated il y a une semaine
Identifier le protocole de communication entre téléphone et ESP32	#3 · opened il y a un mois by arthur caron	CLOSED	updated il y a 2 semaines
chatbot présentation CPE	#2 · opened il y a un mois by arthur caron	Done	CLOSED updated il y a une semaine
Chatbot presentation CPE	#1 · opened il y a un mois by antoine-rb	Done	CLOSED updated il y a une semaine

Échier Édition Croquis Outils Aide

```
// Display test
display.print("Let's go until detection!");
display.setTextSize(1);

// Create a partial T4 memory
// Lancer la processus
display.println("GO !");
for (int i = 0; i < 1000; i++)
{
    // Get usage from processor
    if (TF7LiteDK != interpreter->Invalidate())
        error_reporter->Report("Image capture failed.");
}

// Run the model on this input and make sure it succeeds
if (TF7LiteDK != interpreter->Invoke())
{
    error_reporter->Report("Invoke failed.");
}

TfLiteTensor* output = interpreter->output[0];

// Process the inference results.
uint8_t person_score = output->data.uint8[PersonIndex];
uint8_t no_person_score = output->data.uint8[NoPersonIndex];
RespondToDetectionError(error_reporter, person_score, no_person_score);
display.clearDisplay();
display.setCursor(0, 0);
display.print("person_score : ");
display.println(person_score);
display.print("no_person_score : ");
display.println(no_person_score);
display.println();
display.println();
if (person_score == no_person_score+120) // on est sur de la détection!
{
    mqtt.publish("cpedemolot/feeds/phone-to-esp", "DETECT"); // client.publish("username/feeds/identifier", "DETECT");
    display.println("DETECT");
    display.display();
    delay(5000);
    break;
}
```

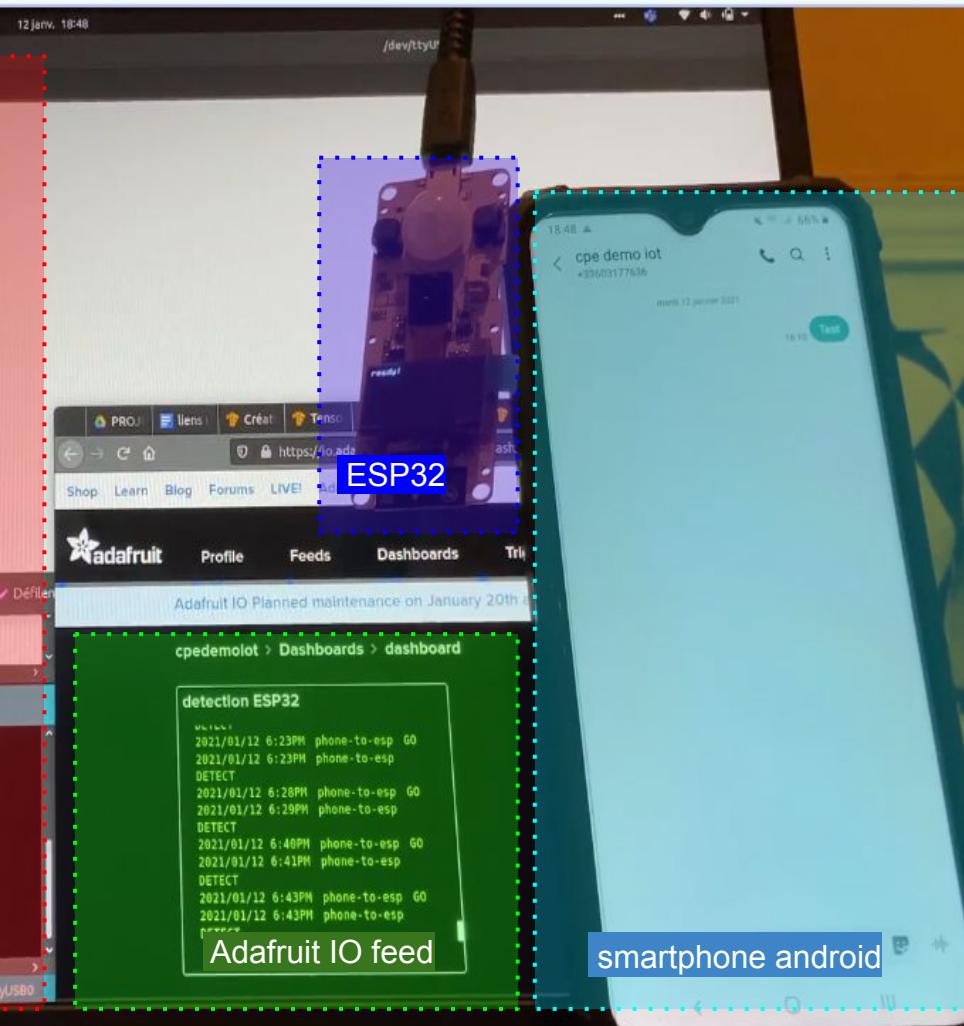
Téléversement terminé

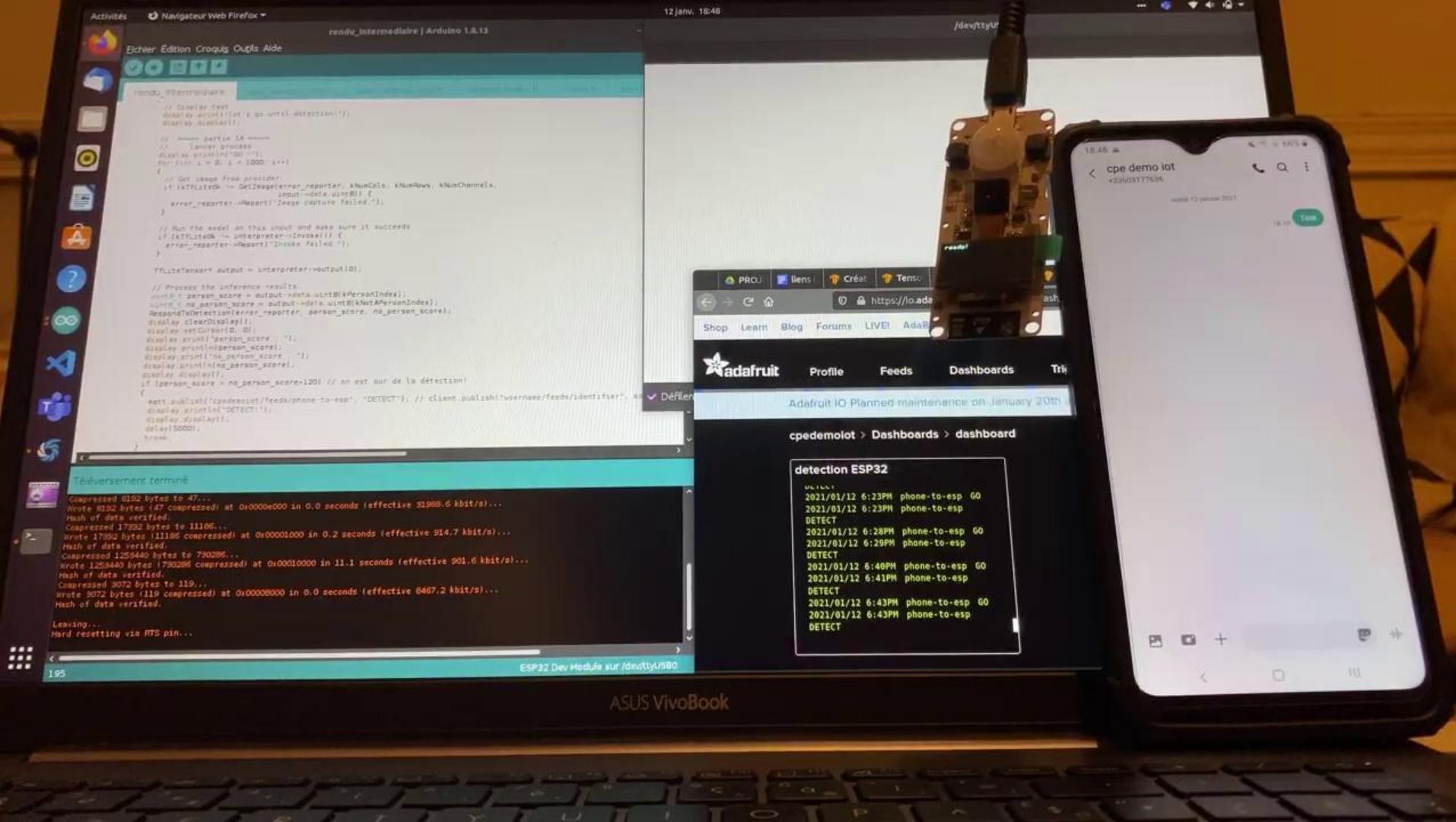
```
Compressed 8192 bytes to 47...
 wrote 8192 bytes (47 compressed) at 0x0000e000 in 0.0 seconds (effective 51298.6 kbit/s)...
 Hash of data verified.
Compressed 37992 bytes to 11186...
 wrote 37992 bytes (11186 compressed) at 0x00001000 in 0.2 seconds (effective 914.7 kbit/s)...
 Hash of data verified.
Compressed 125440 bytes to 730286...
 wrote 125440 bytes (730286 compressed) at 0x00010000 in 11.1 seconds (effective 901.6 kbit/s)...
 Hash of data verified.
Compressed 3972 bytes to 119...
 wrote 3972 bytes (119 compressed) at 0x00008000 in 0.0 seconds (effective 8457.2 kbit/s)...
 Hash of data verified.

Leaving...
Hard resetting via RTS pin...
```

Arduino IDE

ASUS VivoBook



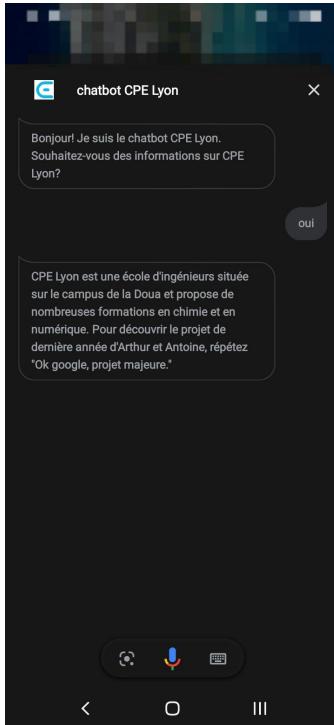
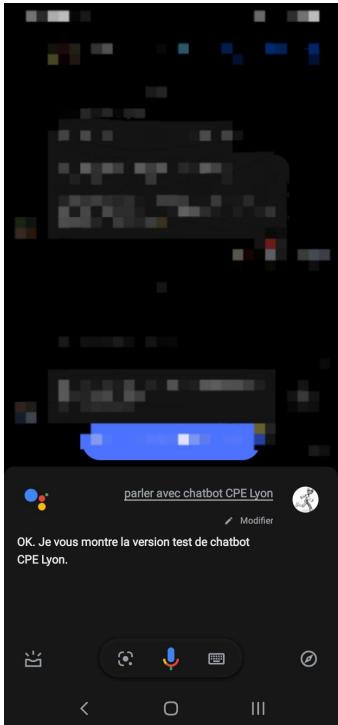


chatbot CPE (1)



chatbot CPE (2)

version mobile :



version tablette :

This screenshot shows a tablet device displaying a light-themed chatbot interface. At the top, a navigation bar includes "Actions Console", "Overview", "Develop", "Test" (which is underlined), "Deploy", and "Analytics". Below the bar is a search bar with the placeholder "Start typing or click the mic and speak". Underneath the search bar are three buttons labeled "oui", "non", and "cancel". A large message box displays a message from the bot: "D'accord. Je vous affiche la version test de chatbot CPE Lyon. Bonjour! Je suis le chatbot CPE Lyon. Souhaitez-vous des informations sur CPE Lyon?". At the bottom of the message box are two blue buttons labeled "oui" and "non". The background of the tablet screen shows a blurred image of a modern building with glass walls.

chatbot CPE (3)

Actions Console Overview **Develop** Test Deploy Analytics

conversation Main invocation

Main invocation French (France)

When user says "Parler avec chatbot CPE Lyon"

Main invocation

When your Action is Invoked

Call your webhook

Send prompts FRENCH (FRANCE)

To provide audio or visual feedback when this event occurs, enter a prompt in the YAML/JSON editor. [Help](#)

YAML **JSON**

```
1 candidates:
  2   - first_simple:
        variants:
          4           - speech: >-
                        Bonjour! Je suis le chatbot CPE Lyon. Souhaitez-vous des
                        informations sur CPE Lyon?
          7 suggestions:
            8   - title: oui
            9   - title: non
```

Insert: content last_simple suggestions

Transition

Select the scene you want the dialog to transition to. [Help](#)

conversation

Errors and warnings ▲ 1 1 NEW Severity ▾

1-1 of 1

chatbot CPE (4)

Actions Console Overview **Develop** Test Deploy Analytics groupe-5-S3 ? ! ... 👤

Invocation 1 ^

conversation X Main invocation X OUI X NON X

conversation French (France) Cancel Save

Settings

Main Invocation

Scenes 1 ^

conversation

+
+

Intents 5 ^

NON

OUI

NO_MATCH SYSTEM

NO_INPUT SYSTEM

CANCEL SYSTEM

+
+

Types 0 ^

Interactive canvas

Webhook

Theme customization

Account linking

Backend services

conversation Transition from actions.intent.MAIN Invocation

Transition to conversation Scene

On enter +

Condition +

Slot filling +

User intent handling +

When OUI is matched → End conversation

When NON is matched → End conversation

Error and status handling +

Intent

Use intents to define which user queries can be matched in this scene. [Help](#)

OUI

When intent is matched

Call your webhook

Send prompts FRENCH (FRANCE)

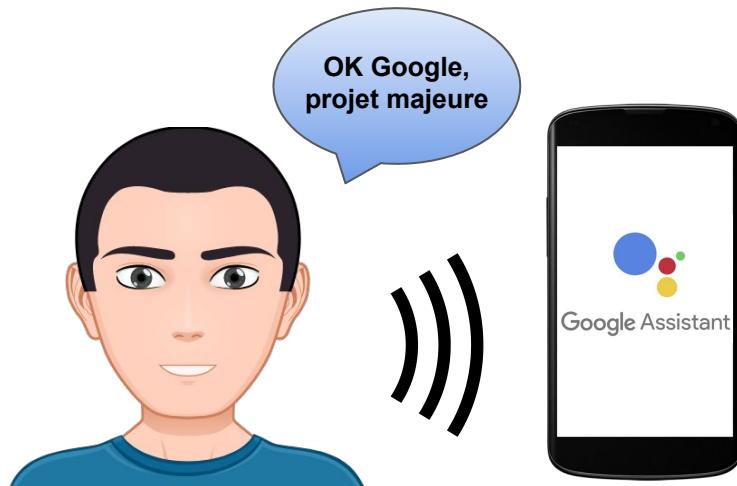
To provide audio or visual feedback when this event occurs, enter a prompt in the YAML/JSON editor. [Help](#)

YAML JSON

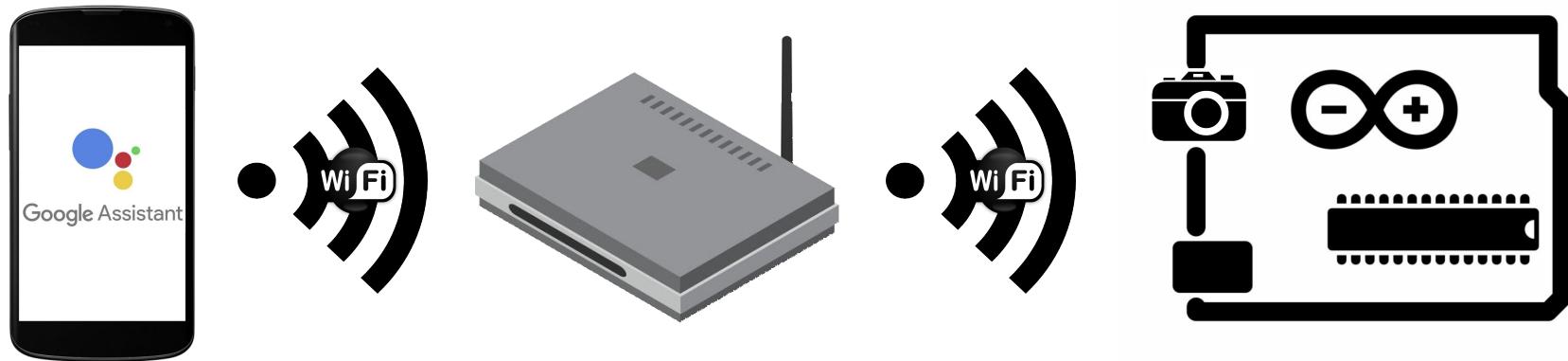
```
1 candidates:
  2   - first_simple:
  3     variants:
  4       - speech: >-
      5         CPE Lyon est une école d'ingénieurs située sur le campus de la
      6         et propose de nombreuses formations en chimie et en numérique.
      7         découvrir le projet de dernière année d'Arthur et Antoine, répé
      8         "Ok google, projet majeure."
      9
```

Errors and warnings Severity ^

scénario défini (1)

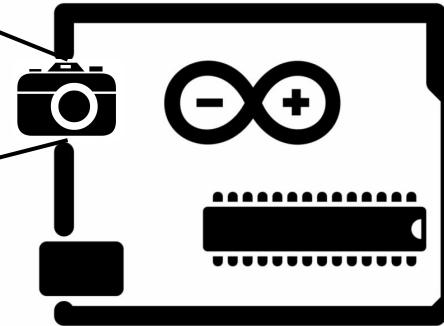


scénario défini (2)

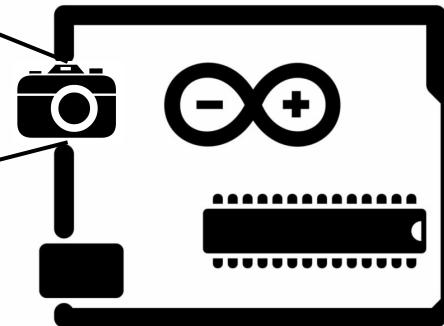
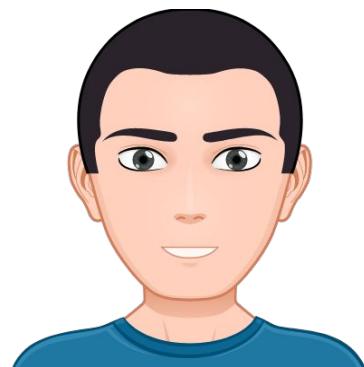


scénario défini (3)

Pas de détection



Détection !



scénario défini (4)

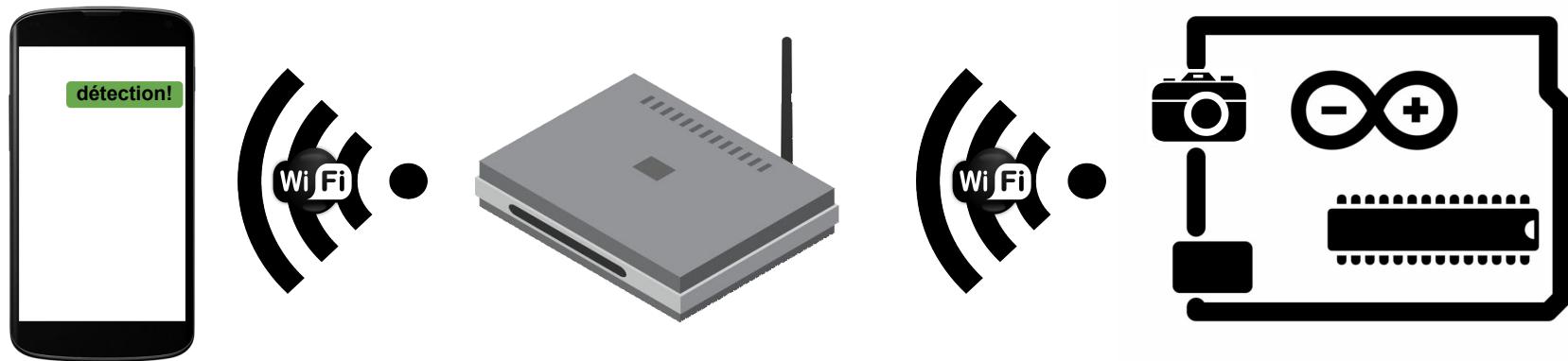
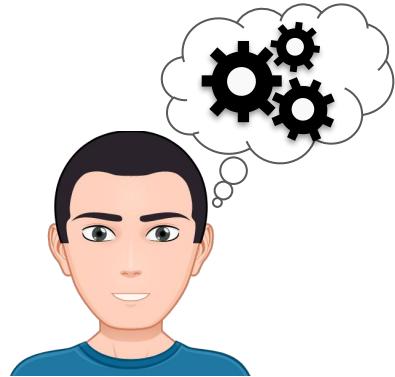
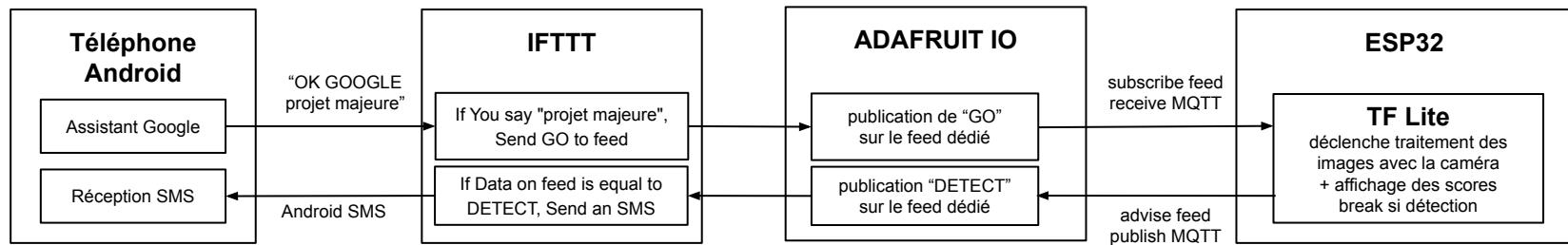


schéma fonctionnel

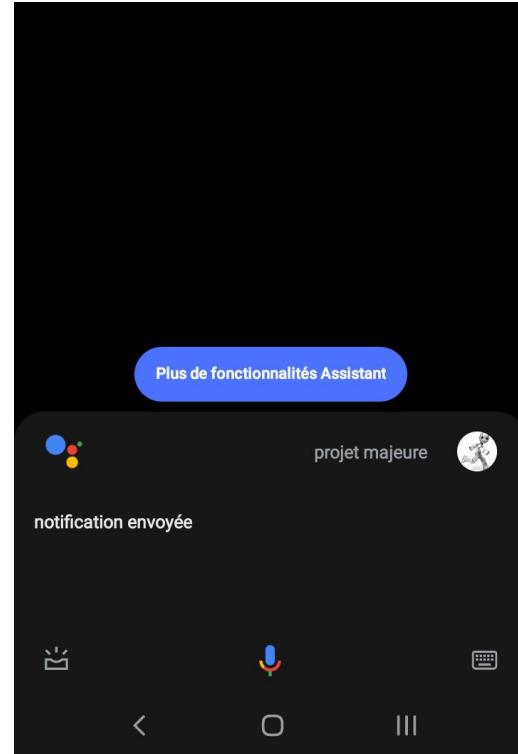


détail (1)



L'ESP32 est :
- connecté au wi-fi
- abonné à un feed

L'assistant google reçoit le mot-clé “projet majeure” : il notify le feed.





If You say "projet majeure", then Send GO to phone_to_esp feed

Edit title

by cpedemoiot

Get notifications when this Applet is active



• Connected Jan 12, 2021
• Last activity Jan 13, 2021
• Run 27 times

[View activity](#)

Realtime Applets usually run within 10 seconds

[Check now](#)

Say a simple phrase

This trigger fires when you say "Ok Google" to the Google Assistant followed by a phrase you choose. For example, say "Ok Google, I'm running late" to text a family member that you're on your way home.

What do you want to say?

projet majeure

What's another way to say it? (optional)

projet majeur

And another way? (optional)

What do you want the Assistant to say in response?

notification envoyée

Language

French



Send data to Adafruit IO

This Action will send data to a feed in your Adafruit IO account.

Feed name

phone-to-esp



The name of the feed to save data to.

Data to save

GO

The data to be saved to your feed.

[Add ingredient](#)

détail (2)

IFTTT permet d'avoir un premier lien, entre l'assistant google et le feed sur adafruit IO

Le feed intitulé "phone-to-esp" reçoit la notification

cpedemoiot > Dashboards > dashboard

detection ESP32

DETECT

2021/01/12 6:40PM phone-to-esp GO

2021/01/12 6:41PM phone-to-esp

DETECT

2021/01/12 6:43PM phone-to-esp GO

2021/01/12 6:43PM phone-to-esp

DETECT

2021/01/12 6:48PM phone-to-esp GO

2021/01/12 6:48PM phone-to-esp

DETECT

détail (3)

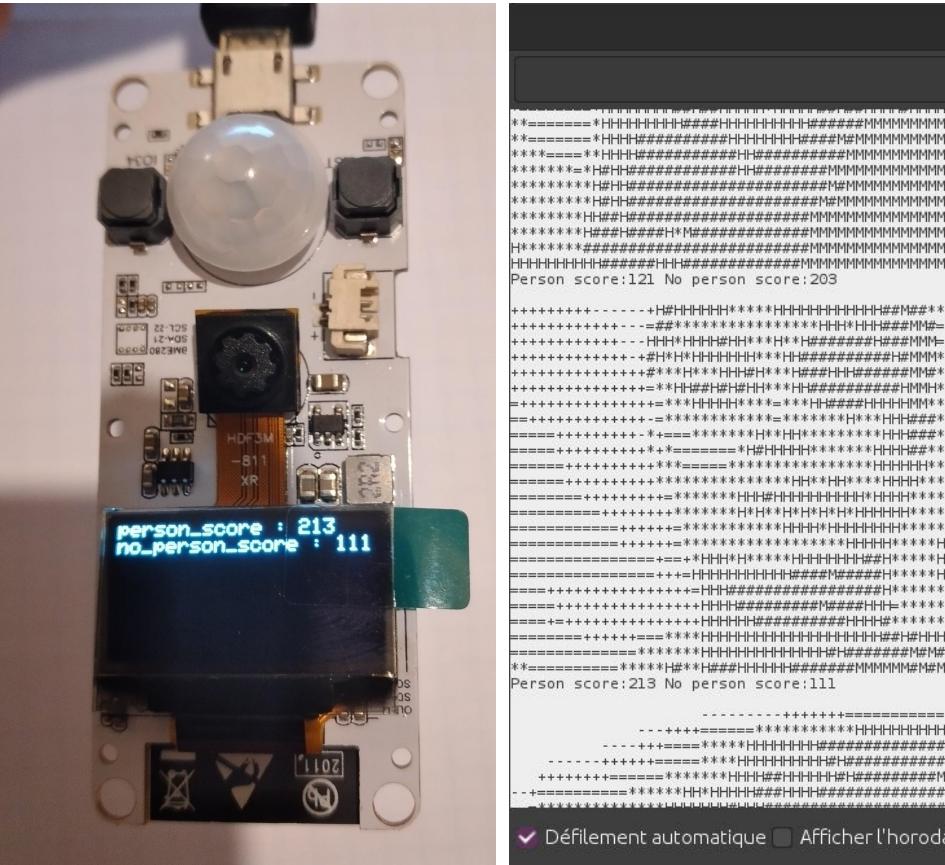
L'ESP32 commence la séquence de détection. Il continue jusqu'à avoir détecté une personne avec sa caméra.

il affiche les scores de chaque image analysée, soit environ toutes les 5 secondes.



détail (4)

Les scores sont encore insuffisants pour l'instant.



Person score:213 No person score:111

On reconnaît quand même un visage sur la console: la détection est proche!

détail (5)



L'ESP32 a détecté
une personne : le
score est assez élevé.
Il notifie le feed.



détail (6)

cpedemoiot > Dashboards > dashboard

detection ESP32

```
DETECT
2021/01/12 6:40PM phone-to-esp GO
2021/01/12 6:41PM phone-to-esp
DETECT
2021/01/12 6:43PM phone-to-esp GO
2021/01/12 6:43PM phone-to-esp
DETECT
2021/01/12 6:48PM phone-to-esp GO
2021/01/12 6:48PM phone-to-esp
DETECT
```

L'ESP32 notify le feed de la détection

IFTTT permet d'avoir un 2ème lien entre le feed et le smartphone android.



If Data on phone-to-esp feed is equal to DETECT, then Send an SMS

by cpedemoiot

Get notifications when
this Applet is active



- Connected Jan 12, 2021
- Last activity Jan 12, 2021
- Run 2 times

[View activity](#)

Polling Appslets usually run within 1 hour

[Check now](#)

Monitor a feed on Adafruit IO

This Trigger fires anytime it validates the data that you send to your feed. Example: If Feed Temperature > 80, fire Trigger.

Feed

phone-to-esp

The name of the feed to check.

Relationship

equal to

Relationship between two values.

Value

DETECT

The value to compare against.

Send an SMS

This Action will send an SMS from your Android device to any phone number you specify.

Phone number

0603177636

Include country code e.g. 12024561111

[Add ingredient](#)

Message

FeedName FeedValue !

[Add ingredient](#)



détail (7)

Le smartphone
Android est notifié par
sms de la détection.

L'ESP 32 retourne en
attente d'une nouvelle
notification sur le feed



Réseau de neurones : ébauche avec Teachable Machine

Création d'un réseau Teachable machine => outil simple, puissant et efficient

Teachable Machine

Train a computer to recognize your own images, sounds, & poses.

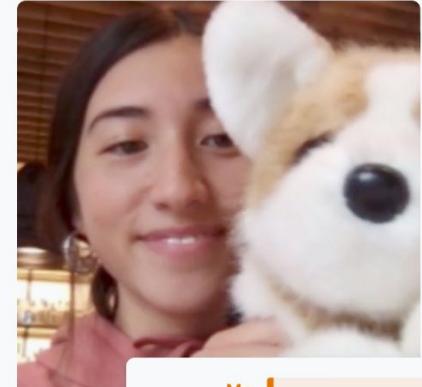
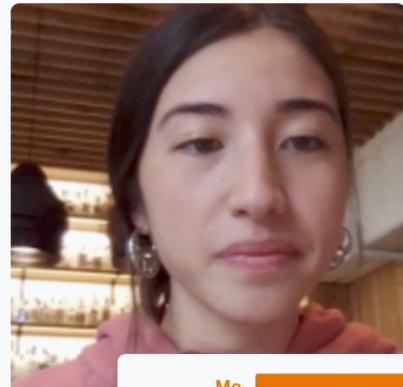
A fast, easy way to create machine learning models for your sites, apps, and more – no expertise or coding required.

[Get Started](#)

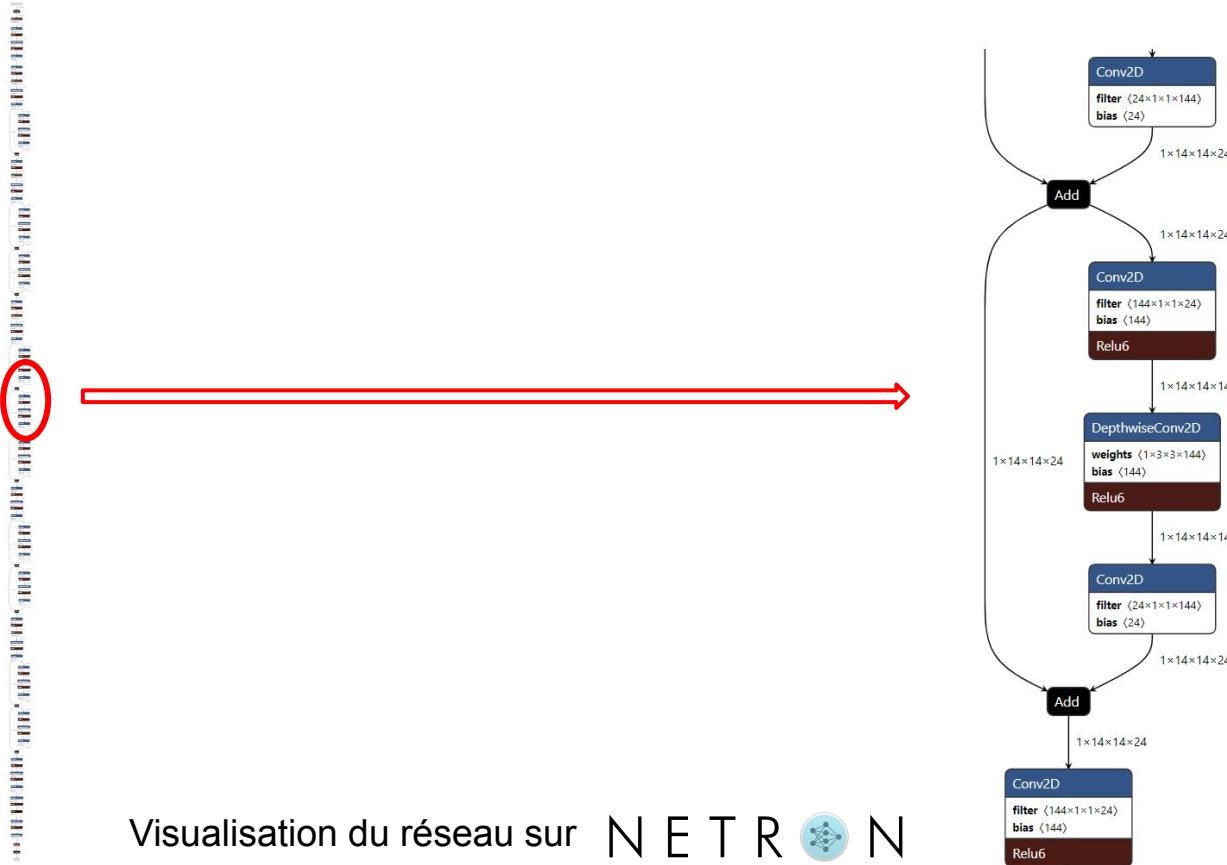


[About](#) [FAQ](#)

[Get Started](#)



Inconvénient majeur : la complexité du réseau de Teachable Machine



Détection de personnes par l'ESP32 avec Tensorflow lite

Visage humain

Réseau de neurone à sortie binaire



Sortie console Arduino IDE

Implémentation d'un nouveau réseau sur la carte (1)



Création d'un modèle de reconnaissance (chien/chat) sur Google Cola

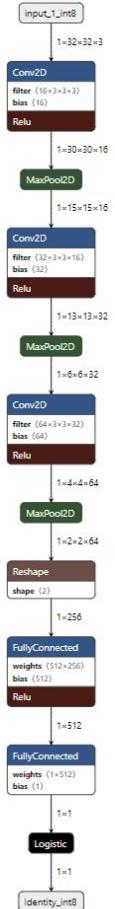
The screenshot shows a Google Colab interface with the following details:

- Title:** image_classification_part1.ipynb
- File menu:** Fichier, Modifier, Affichage, Insérer, Exécution, Outils, Aide
- Code tab:** + Code, + Texte, Copier sur Drive
- Search bar:** Copyright 2018 Google LLC.
- Code area:**

```
> Copyright 2018 Google LLC.  
<> 1 cellule masquée  
↳ Cat vs. Dog Image Classification  
Exercise 1: Building a Convnet from Scratch  
Estimated completion time: 20 minutes  
In this exercise, we will build a classifier model from scratch that is able to distinguish dogs from cats. We will follow these steps:  
1. Explore the example data  
2. Build a small convnet from scratch to solve our classification problem  
3. Evaluate training and validation accuracy  
Let's go!  
↳ Explore the Example Data  
Let's start by downloading our example data, a .zip of 2,000 JPG pictures of cats and dogs, and extracting it locally in /tmp.  
NOTE: The 2,000 images used in this exercise are excerpted from the Dogs vs. Cats dataset available on Kaggle, which contains 25,000 images. Here, we use a subset of the full dataset to decrease training time for educational purposes.
```



- Taille du dataset (training + validation) = 2000
- Diminution de la taille des images
- Architecture du modèle (convolutions)
- Sortie binaire (chien ou chat)



Framework et API utilisés



TensorFlow Lite

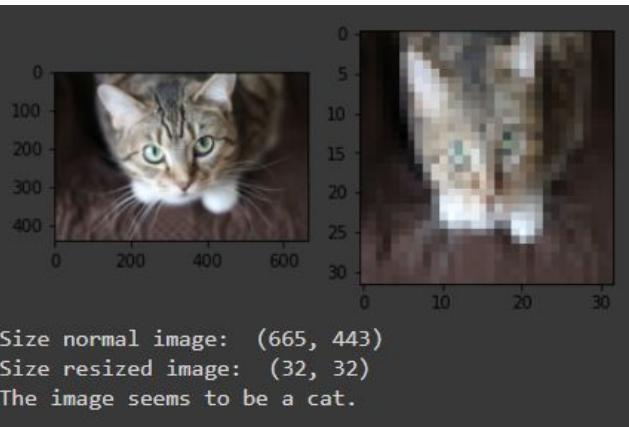
Framework Open Source de deep learning embarqué



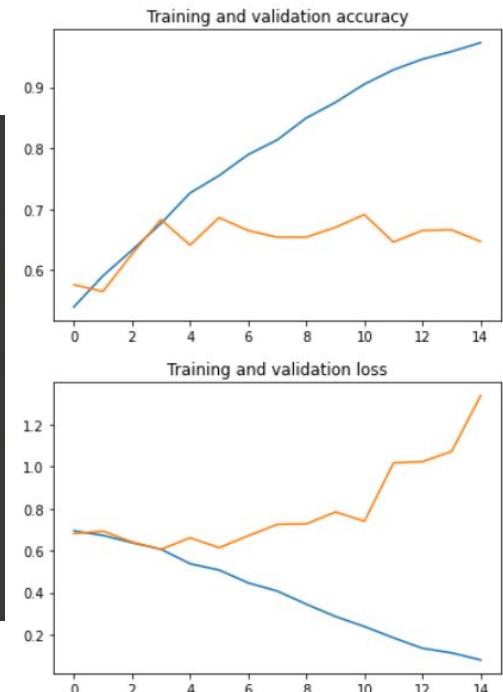
API qui simplifie l'utilisation de TFLite sur python

Modèle de reconnaissance d'image (chien / chat)

Test du modèle sur des images externes



Evaluation de la précision et des pertes



Surapprentissage !

Implémentation d'un nouveau réseau sur la carte (2)

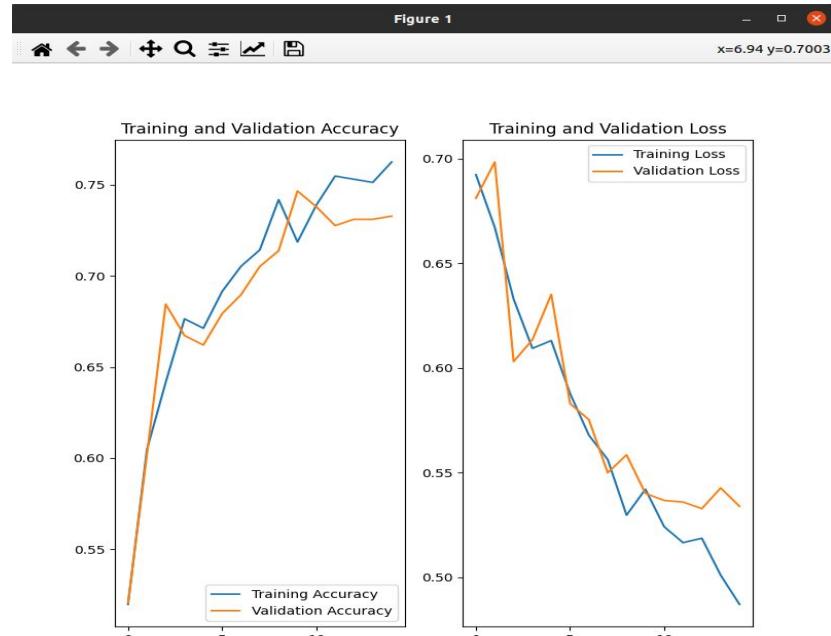
(modèle d'Arthur, adapté au dataset chien/chat)

```
132
133 model = Sequential([
134     data_augmentation,
135     layers.experimental.preprocessing.Rescaling(1./255),
136     layers.Conv2D(16, 3, activation='relu'),
137     layers.MaxPooling2D(),
138     layers.Conv2D(32, 3, activation='relu'),
139     layers.MaxPooling2D(),
140     layers.Conv2D(64, 3, activation='relu'),
141     layers.MaxPooling2D(),
142     layers.Dropout(0.2),
143     layers.Flatten(),
144     layers.Dense(128, activation='relu'),
145     layers.Dense(num_classes)
146 ])
147
148 """## Compile and train the model"""
149
150 model.compile(optimizer='adam',
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
```

dense (Dense)	(None, 128)	295040
dense_1 (Dense)	(None, 2)	258

Total params: 318,882
Trainable params: 318,882
Non-trainable params: 0

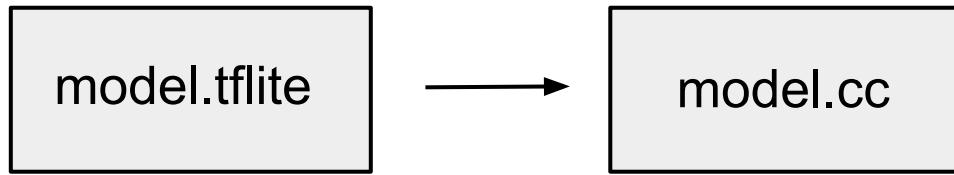
```
Epoch 1/15
2021-01-20 21:18:35.114359: W tensorflow/core/framework/cpu_allocator.cc:80] Allocation of 18911232 exceeds 10% of free system memory.
2021-01-20 21:18:35.114655: W tensorflow/core/framework/cpu_allocator.cc:80] Allocation of 18911232 exceeds 10% of free system memory.
2021-01-20 21:18:35.119414: W tensorflow/core/framework/cpu_allocator.cc:80] Allocation of 25189632 exceeds 10% of free system memory.
2021-01-20 21:18:35.119545: W tensorflow/core/framework/cpu_allocator.cc:80] Allocation of 25189632 exceeds 10% of free system memory.
2021-01-20 21:18:35.141890: W tensorflow/core/framework/cpu_allocator.cc:80] Allocation of 19927296 exceeds 10% of free system memory.
[=====[ 0%] - 3s 73ms/step - loss: 0.6959 - accuracy: 0.4991 - val_loss: 0.6811 - val_accuracy: 0.3287
Epoch 2/15
73/73 [=====] - 3s 37ms/step - loss: 0.6767 - accuracy: 0.5941 - val_loss: 0.6984 - val_accuracy: 0.6017
Epoch 3/15
73/73 [=====] - 3s 35ms/step - loss: 0.6344 - accuracy: 0.6450 - val_loss: 0.6031 - val_accuracy: 0.6845
Epoch 4/15
73/73 [=====] - 3s 41ms/step - loss: 0.6114 - accuracy: 0.6785 - val_loss: 0.6135 - val_accuracy: 0.6672
Epoch 5/15
73/73 [=====] - 3s 47ms/step - loss: 0.6250 - accuracy: 0.6625 - val_loss: 0.6352 - val_accuracy: 0.6621
Epoch 6/15
45/73 [=====] - ETA: 1s - loss: 0.5916 - accuracy: 0.6981
```



Environ 70% de réussite mais ne fonctionne pas sur l'ESP32 → frustration !!

Conversion du modèle modèle .tflite en modèle cc

- Export du modèle en fichier tflite
- Conversion du modèle en format compatible pour l'ESP32



Format binaire

Tableau de valeurs hexadécimales

```
os.system ("xxd -i model.tflite > model.cpp")
```

```
const unsigned char g_cat_dog_detect_model_data[] DATA_ALIGN_ATTRIBUTE = {  
    0x20, 0x00, 0x00, 0x54, 0x46, 0x4c, 0x33, 0x00, 0x00, 0x00, 0x00,  
    0x00, 0x00, 0x12, 0x00, 0x1c, 0x00, 0x18, 0x00, 0x14, 0x00, 0x10, 0x00,  
    0x0c, 0x00, 0x08, 0x00, 0x00, 0x00, 0x04, 0x00, 0x00, 0x12, 0x00, 0x00, 0x00,  
    0x18, 0x00, 0x00, 0x48, 0x00, 0x00, 0x00, 0xfc, 0x68, 0x02, 0x00,  
    0x0c, 0x69, 0x02, 0x00, 0x4, 0x86, 0x02, 0x00, 0x03, 0x00, 0x00, 0x00,  
    0x01, 0x00, 0x00, 0x0c, 0x00, 0x00, 0x00, 0x08, 0x00, 0x0c, 0x00, 0x00,  
    0x08, 0x00, 0x04, 0x00, 0x08, 0x00, 0x00, 0x00, 0x17, 0x00, 0x00, 0x00,  
    0x04, 0x00, 0x00, 0x00, 0x13, 0x00, 0x00, 0x00, 0x6d, 0x69, 0x6e, 0x5f,  
    0x72, 0x75, 0x6e, 0x74, 0x69, 0x6d, 0x5f, 0x76, 0x65, 0x72, 0x73,  
    0x69, 0x6f, 0x6e, 0x00, 0x18, 0x00, 0x00, 0x00, 0xb0, 0x68, 0x02, 0x00,  
    0xa8, 0x68, 0x02, 0x00, 0x58, 0x60, 0x02, 0x00, 0xc0, 0x67, 0x02, 0x00,  
    0xb0, 0x66, 0x02, 0x00, 0xa0, 0x5e, 0x02, 0x00, 0x8c, 0x5e, 0x02, 0x00,  
    0x74, 0x5e, 0x02, 0x00, 0x64, 0x5e, 0x00, 0x00, 0x54, 0x5c, 0x00, 0x00,  
    0x94, 0x5a, 0x00, 0x00, 0x84, 0x48, 0x00, 0x00, 0x74, 0x00, 0x00, 0x00,  
    0x6c, 0x00, 0x00, 0x64, 0x00, 0x00, 0x00, 0x5c, 0x00, 0x00, 0x00,  
    0x54, 0x00, 0x00, 0x4c, 0x00, 0x00, 0x00, 0x44, 0x00, 0x00, 0x00,  
    0x3c, 0x00, 0x00, 0x00, 0x34, 0x00, 0x00, 0x00, 0x2c, 0x00, 0x00, 0x00,  
    0x24, 0x00, 0x00, 0x04, 0x00, 0x00, 0x00, 0x06, 0x98, 0xfd, 0xff,  
    0x04, 0x00, 0x00, 0x10, 0x00, 0x00, 0x00, 0x31, 0x2e, 0x31, 0x34,  
    0x2e, 0x30, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}
```

Implémentation du nouveau réseau de neurones (chien / chat) sur l'ESP32

Adaptation du code à notre modèle

```
constexpr int kNumCols = 32;
constexpr int kNumRows = 32;
constexpr int kNumChannels = 3;

const char* kCategoryLabels[kCategoryCount] = {
    "unused",
    "cat",
    "dog",
};

static tflite::MicroMutableOpResolver micro_mutable_op_resolver;

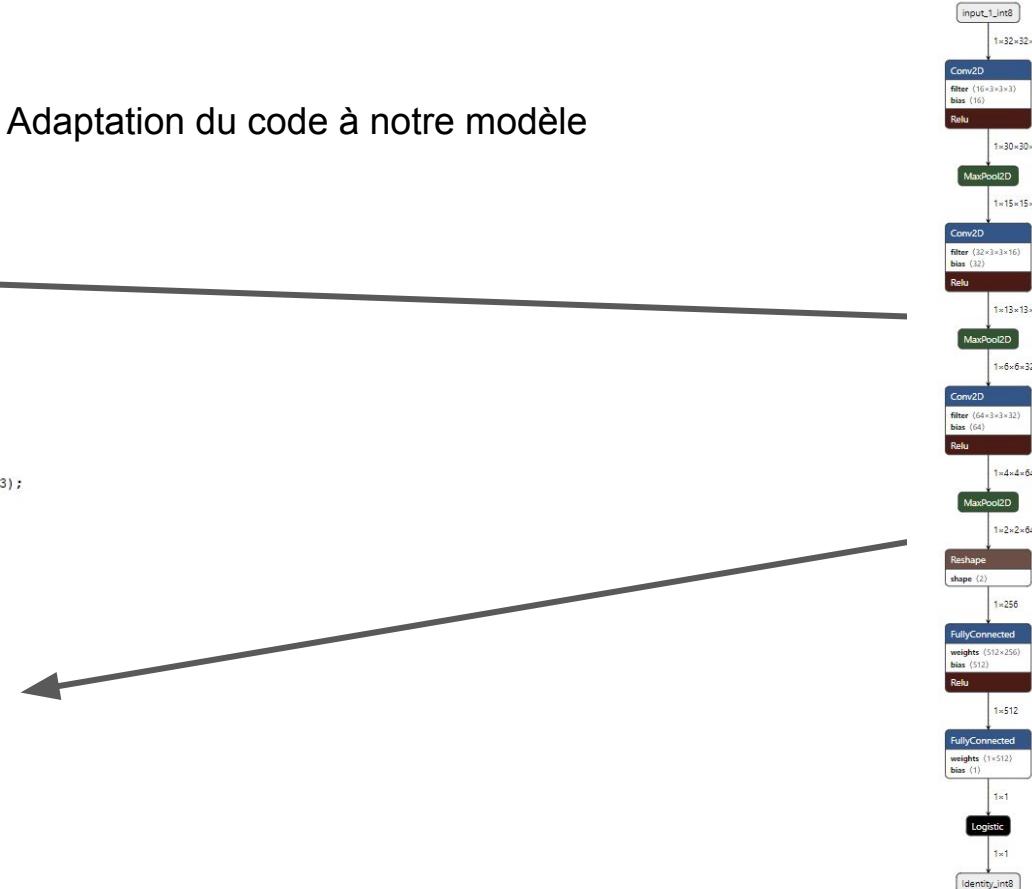
micro_mutable_op_resolver.AddBuiltin(tflite::BuiltinOperator_CONV_2D,
                                      tflite::ops::micro::Register_CONV_2D(), 1, 3);

micro_mutable_op_resolver.AddBuiltin(
    tflite::BuiltinOperator_MAX_POOL_2D,
    tflite::ops::micro::Register_MAX_POOL_2D(), 1, 2);

micro_mutable_op_resolver.AddBuiltin(
    tflite::BuiltinOperator_FULLY_CONNECTED,
    tflite::ops::micro::Register_FULLY_CONNECTED(), 1, 4);

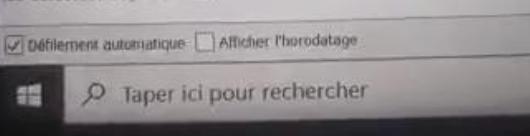
micro_mutable_op_resolver.AddBuiltin(
    tflite::BuiltinOperator_RESHAPE,
    tflite::ops::micro::Register_RESHAPE());

micro_mutable_op_resolver.AddBuiltin(
    tflite::BuiltinOperator_LOGISTIC,
    tflite::ops::micro::Register_LOGISTIC(), 1, 2);
```



Extraits de code de notre code

```
Type DATA not currently supported.  
Mode MAX_POOL_3D (number 1) failed to invoke with status 1  
Format: Tex Input  
Get score:149 Dog score:128  
  
XXXXXXXXXXXXXX  
XXXXXXXXXXXXXX  
XXXXXXXXXXXXXX  
XXXXXXXXXXXXXX  
+> 0000000000000000  
- - 0000000000000000  
R: - 0000000000000000  
Z: +0000000000000000  
  
Type IXIN not currently supported.  
Mode MAX_POOL_2D (number 1) failed to invoke with status 1  
Format: Tex Input  
Get score:150 Dog score:128  
  
XXXXXXXXXXXXXX  
XXXXXXXXXXXXXX  
XXXXXXXXXXXXXX  
XXXXXXXXXXXXXX  
1000000000000000  
H0000000000000000  
P: +0000000000000000  
R: - 0000000000000000  
Z: +0000000000000000  
  
Type IXIN not currently supported.  
Mode MAX_POOL_2D (number 1) failed to invoke with status 1  
Format: Tex Input  
Get score:145 Dog score:128
```



Tests complexes car :

- on filme un **écran**,
 - **l'angle** de la caméra,
 - **l'image** elle-même...

Pistes d'amélioration

- Connaissances spécifiques sur tensorflow / keras pour ESP32 !!
- Trier nos images (big data) pour avoir un dataset plus grand et plus pertinent
- Intégration complète dans le projet
- Créer un réseau avec notre propre dataset, plus grand que celui ci => améliorer performances

Bilan, conclusion

Cahier des charges respecté



Mais fiabilité aléatoire



- Syndrome de la boîte noire : on ne maîtrise pas TFLite sur ESP32



+ Intégration de nombreuses technos différentes en peu de temps

+ Importance du travail de recherche et d'intégration des résultats

+ Binôme solide : bonne répartition du travail, bonne ambiance