

**HAUTE ECOLE DE NAMUR-LIEGE-LUXEMBOURG**

**Ecole d'Ingénieurs**

**PIERRARD - VIRTON**

***Master Ingénieur Industriel Automatisation***

## Systèmes intelligents – Rapport de projet

.

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# Introduction

## Description of the project

As part of the deep learning course, we were tasked with a project that focuses on image recognition and classification based on convolutional neural networks algorithms implemented by python libraries, specifically PyTorch.

The subject of the project is the recognition and classification of bird images. This project aims to develop a bird species recognition system using a Raspberry Pi with a camera module. The system will identify birds in real-time and store a history of all recognized species along with corresponding images. The goal is to create an automated bird monitoring system that logs bird sightings, providing insights into species diversity in a given area.

## Description of required equipment

In order to build the bird species recognition system, we need a labelled dataset of bird species. It is important to choose the dataset correctly as it defines the outputs or classes of the model. Many of the datasets found online feature hundreds of species that are not found in Belgium or Europe even, so they do not correspond to our classification need as we do not intend to test the model internationally.

To have an idea of the species that we have the possibility of encountering with our system, we checked some databases of bird species found around where we live. Also, we have decided to test the model exclusively near bird feeders in order to have a clear picture of birds standing still and close to the camera, and to increase the likelihood of testing the model on as many specimens as possible as well as many different species.

Therefore, we have limited the species that we are interested in classifying to the ones that are found near Virton and can fit in bird feeders. These species are essentially: blue and coal tits (mésanges), blackbirds, crows, pigeons, magpies, doves, dunnocks, chaffinches, goldfinches, greenfinches, sparrows, jackdaws, robins, thrushes and starlings.

Sources for species found : <https://avibase.bsc-eoc.org/checklist.jsp?lang=EN&p2=1&list=howardmoore&synlang=&region=BE&version=text&lifelist=&highlight=0>

The chosen dataset is called 20\_UK\_Garden\_Birds and was found on Kaggle. This bird dataset offers 3000 images across 20 classes, with 150 images per species. The vast majority of images from this dataset are images captured from the internet. It features a limited number of species compared to most other datasets. However, UK garden birds are quite similar to those found in Belgium. Both countries share a temperate climate and similar habitats, leading to a high overlap in bird species. Thus, we found it relevant for our project.

Source for the dataset: [20\_UK\_Garden\_Birds](https://www.kaggle.com/datasets/davemahony/20-uk-garden-birds?select=birds.csv)

We developed our own convolutional neural network (CNN) to train our model with the dataset described above. The training aspect of our project is an iterative process to find the neural network configuration and parameters that provide the best results, and it can become very timely. Faster training requires computational power found in a discrete GPU. We used the Nvidia RTX 4070 to train our model and optimize it for deployment on Raspberry Pi. The Python library used is PyTorch and not TensorFlow because it offers the possibility of training the CNN on the GPU under Windows OS.

Data Augmentation for Training

To improve the generalization of the model, various data augmentation techniques will be applied to the training dataset:

* Rotation – Randomly rotating images to handle different bird orientations.
* Flipping – Horizontally flipping images to increase variability.
* Cropping and Scaling – Adjusting image sizes to prevent overfitting.
* Color Jittering – Slightly altering brightness, contrast, and saturation.
* Gaussian Noise Addition – Simulating different lighting conditions.
* Random Occlusions – Simulating partial obstructions by branches or leaves.

Write about data augmentation techniques that will actually be used.

We used a Raspberry Pi 5 as the main processing unit for testing the model outside due to its small size and transportability and a Raspberry Pi camera module to capture the images of the birds. We used a storage device connected to the Raspberry Pi to store the operating system, the model data and the database for the bird sighting history along with images. The library OpenCV was used for image processing with the camera.

## Diagram of the project

The training of the model starts with dataset preparation. This includes the selection of an existing dataset and the expansion this dataset through the application of data augmentation techniques, that allow for improved model robustness.

Then, the CNN model is built and trained with the GPU, using PyTorch. The model is finally validated with the test data.

Model Optimization for Raspberry Pi

* Convert the trained model to TensorFlow Lite format (.tflite) for efficient execution.
* Apply quantization (e.g., post-training quantization) to reduce model size and improve inference speed.
* Test inference speed on the Raspberry Pi and adjust parameters as needed.

The optimized model is deployed and loaded onto the Raspberry Pi and is integrated with the camera module for real time predictions. Predictions and related images are stored in the local database.

The flow of data is as follows: the camera module captures an image, which is processed by the Raspberry Pi. If the image features a bird, the CNN model classifies the bird species, and the database stores the species name, timestamp and image.

Will there be a dashboard or a web interface to display stored data ?

## Timeline with validation steps

The first task is an analysis of the project, this task helps us define the exact subject and the perimeter of the project. It includes an exhaustive description of the project, and the equipment required, as well as a diagram of the project. The validation criteria for this task are the agreement and definition of the project between the members of the group and the validation by the teacher.

The second task is the research and selection of a dataset of images that are already arranged with labels and that is relevant to our application. Additionally, if this dataset does not require much tuning on our part, including data augmentation or increasing the number of species outputs, it is better. The validation criterium for this task is the selection of the dataset.

The third task is programming the CNN model in Python, training and testing the model with the dataset and optimizing the model. We use the accuracy from the model testing to compare the different models and select the best one. We also compare our results with other exiting models. The validation criteria are when the accuracy reaches a certain value we are satisfied with, at the very least 80%, and the model is as small as possible with no compromises on the accuracy.

The fourth task is implementing the image capture and processing and building the database stores the history of species name, timestamp and image of interest. A visualization is also developed to access the database easily. The validation criterium is field testing and validating of the species recognition system, namely its accuracy will be verified with real birds and the system works reliably in real world conditions.

The last task is documenting, specifically preparing the PowerPoint presentation and writing the report for the evaluation of the project.

The distribution of tasks within the group remains to be discussed.

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Add final or reviewed version of Gantt chart ?

## State of the art of the existing

**5. State of the Art - Existing Projects**

Several bird recognition projects exist, including:

1. **Merlin Bird ID (Cornell Lab of Ornithology)** – A mobile app using deep learning to identify birds from photos and sounds.
2. **iNaturalist** – A citizen science platform where users can identify species using an AI-powered system.
3. **BirdNET** – A real-time bird sound recognition system based on deep learning.
4. **DIY Raspberry Pi Bird Detectors** – Some projects on GitHub use OpenCV and TensorFlow for recognizing birds in backyard feeders.

These projects serve as inspiration but do not always focus on real-time processing with a Raspberry Pi and local storage. Our project bridges this gap by providing an affordable, standalone bird species recognition system.

This document outlines the necessary steps and resources for successful implementation. Would you like any modifications or additional details?

**6. State of the Art - Existing Models for Comparison**

Several pre-trained models exist for bird species recognition, providing benchmarks for evaluating the custom CNN:

1. **ResNet50 (Fine-Tuned on iNaturalist)**
   * Strong feature extraction capabilities.
   * High accuracy but computationally intensive.
   * Can be pruned and quantized for Raspberry Pi.
2. **MobileNetV2 (Optimized for Edge Devices)**
   * Lightweight and fast.
   * Moderate accuracy but well-suited for Raspberry Pi.
3. **EfficientNet-Lite**
   * Balances efficiency and accuracy.
   * Optimized for mobile and edge deployment.
4. **YOLOv5 (For Real-Time Object Detection)**
   * Can detect multiple birds in a single frame.
   * Requires higher computational resources.

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