Self-explainable model for audio identification of bird species

Keywords: Explainable AI, Bio-Acoustics, Convolutional Neural Networks

Institution

The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development, and innovation. Drawing on the widely acknowledged expertise gained by its 16,000 staff spanned over 9 research centers with a budget of 4.1 billion Euros, CEA actively participates in more than 400 European collaborative projects with numerous academic (notably as a member of Paris-Saclay University) and industrial partners. Within the CEA Technological Research Division, the CEA List institute addresses the challenges coming from smart digital systems.

Among other activities, CEA List's Software Safety and Security Laboratory (LSL) research teams design and implement automated analysis in order to make software systems more trustworthy, to exhaustively detect their vulnerabilities, to guarantee conformity to their specifications, and to accelerate their certification. The lab recently extended its activities on the topic of AI trustworthiness and gave birth to a new research group: AISER (Artificial Intelligence Safety, Explainability and Robustness).

Scientific context

Through the recent developments of AI, the use of models produced by machine learning has become widespread, even in industrial settings. However, studies are flourishing showing the dangers that such models can bring, in terms of safety, privacy or even fairness. To mitigate these dangers and improve trust in AI, one possible avenue of research consists in designing methods for generating *explanations* of the model behaviour. Such methods, regrouped under the umbrella term "eXplainable AI" (XAI), empower the user by providing them with relevant information to make an informed choice to trust the model (or not).

In particular, rather than attempting to explain the model behaviour after it has been trained (*post-hoc* explanations), some XAI methods propose to enforce explainability constraints directly during the design phase of the machine learning process, resulting in so-called *self-explainable models*. In this regard, case-based reasoning is currently considered a viable alternative to more opaque “black box” convolutional neural networks (CNN), with works such as (Chen et al. 2019) or (Nauta, Bree, and Seifert 2021). In case-based reasoning, new instances of a problem are solved by drawing comparisons with examples encountered before, such that the decision is taken and motivated by the fact that the new instance resembles some known cases (also called *prototypes*). CEA-LIST has already developed an open-source library for case-based reasoning networks, called CaBRNet(Xu-Darme et al. 2024), and wish to extend its application to new domains and modalities.

Internship

This internship focuses on the use of machine learning models for the recognition and classification of bird songs. Audio clips are often encoded in the form of spectrograms, *i.e.* 2D representations of the intensity of the signal at various frequencies, across a given period of time. Since spectograms can be interpreted as images, a common practice consists in processing them using deep CNNs originally designed for computer vision (Kahl et al. 2021). Hence, the goal of the internship is to extend the case-based reasoning approach to this new task, by adapting existing computer vision methods to learn audio prototypes. In particular, the new approach will take into account the temporal specificities of audio samples. Indeed, contrary to computer vision models which are spacially invariant (the nature of an object remains identical regardless of its position inside the image), spatial location is crucial in spectograms as it corresponds to different frequency ranges and different period of times.

In practice, the internship will be split in several subtasks as follows:

- Establish a baseline using the reference BirdNET model.
- Identify a body of existing works on self-explainable models for audio classification
- Design and train a case-based reasoning model for audio classifiation, using the CaBRNet framework.

Qualifications

As it is not realistic to be expert in machine-learning, bio-acoustic and XAI, we encourage candidates that do not meet the full qualification requirements to apply nonetheless. We strive to provide an inclusive and enjoyable workplace. We are aware of discriminations based on gender (especially prevalent on our fields), race or disability, we are doing our best to fight them.

- **Minimal**
  - Master student or equivalent (2nd/3rd engineering school year) in computer science
  - knowledge of Python and the Pytorch framework
  - ability to work in a team, some knowledge of version control
- **Preferred**

- notions of AI and neural networks
- notions of Computer Vision
- notions of bio-acoustics
- notions of explainable AI

Characteristics

The candidate will be supervised by two research engineers.

- **Duration:** 5 to 6 months from early 2024
- **Location:** CEA Grenoble
- **Compensation:**
  - 1400€ monthly stipend
  - possible allowance for housing and travel expense (in case a relocation is needed)
  - 75% refund of transit pass
  - subsidized lunches
  - 3 days of remote work

Application

If you are interested in this internship, please send to the contact persons an application containing:

- your resume;
- a cover letter indicating how your curriculum and experience match the qualifications expected and how you would plan to contribute to the project;
- your bachelor and master 1 transcripts;

Applications are welcomed until the position is filled. Please note that the administrative processing may take up to 3 months.

Contact persons

For further information or details about the internship before applying, please contact:

- Alban Grastien (alban.grastien@cea.fr)
- Romain Xu-Darme (romain.xu-darme@cea.fr)

References

Chen, Chaofan, Oscar Li, Chaofan Tao, Alina Jade Barnett, Jonathan Su, and Cynthia Rudin. 2019. "*This* Looks Like *That*: Deep Learning for Interpretable Image Recognition." *Proceedings of the 33rd International Conference on Neural Information Processing Systems*, 8930–41.

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