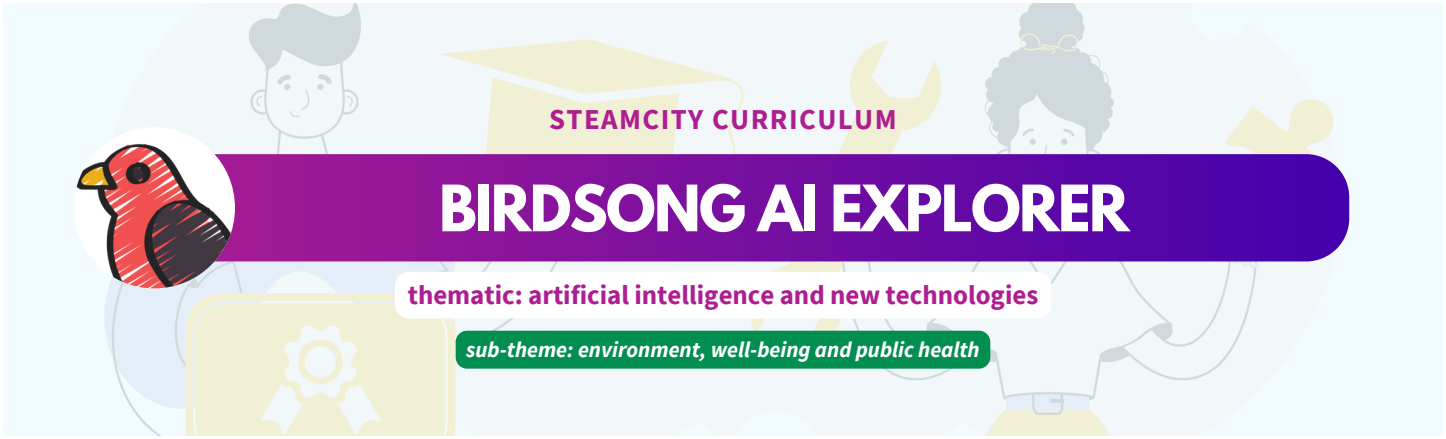


STEAMCITY CURRICULUM

BIRDSONG AI EXPLORER

thematic: artificial intelligence and new technologies

sub-theme: environment, well-being and public health

Introduction

This activity immerses students in the **identification of birds** and the understanding of **bird songs**, emphasizing the application of **Artificial Intelligence (AI)** and **supervised learning**. Through interactive sessions, participants will gain a comprehensive understanding of various bird species while exploring the intersection between technology and ornithology. The objective is to foster a deeper appreciation for **urban biodiversity** and to demonstrate the potential of AI tools in conservation efforts, aligning with the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land).

The activity aims to:

1. **Develop an understanding** of the role of urban birds and their ecological significance, highlighting their contribution to urban biodiversity and ecosystems.
2. **Teach students** how to identify different bird species by listening to their songs, thereby enhancing their observational skills and knowledge of avian communication.
3. Introduce the concept of **supervised learning** and demonstrate the use of AI tools, such as Google Teachable Machine, to recognize bird sounds.
4. **Explore the impact** of urbanization on bird populations and biodiversity, emphasizing the relationship between urban development and ecological balance.
5. Enable students to create a **visual representation** of urban bird diversity by geotagging and mapping bird songs, fostering an understanding of the spatial distribution of bird species in urban areas. </aside>

Interdisciplinarity

Computer Science

Biology

Sustainable Development Goals

Overview

Protocol Structure

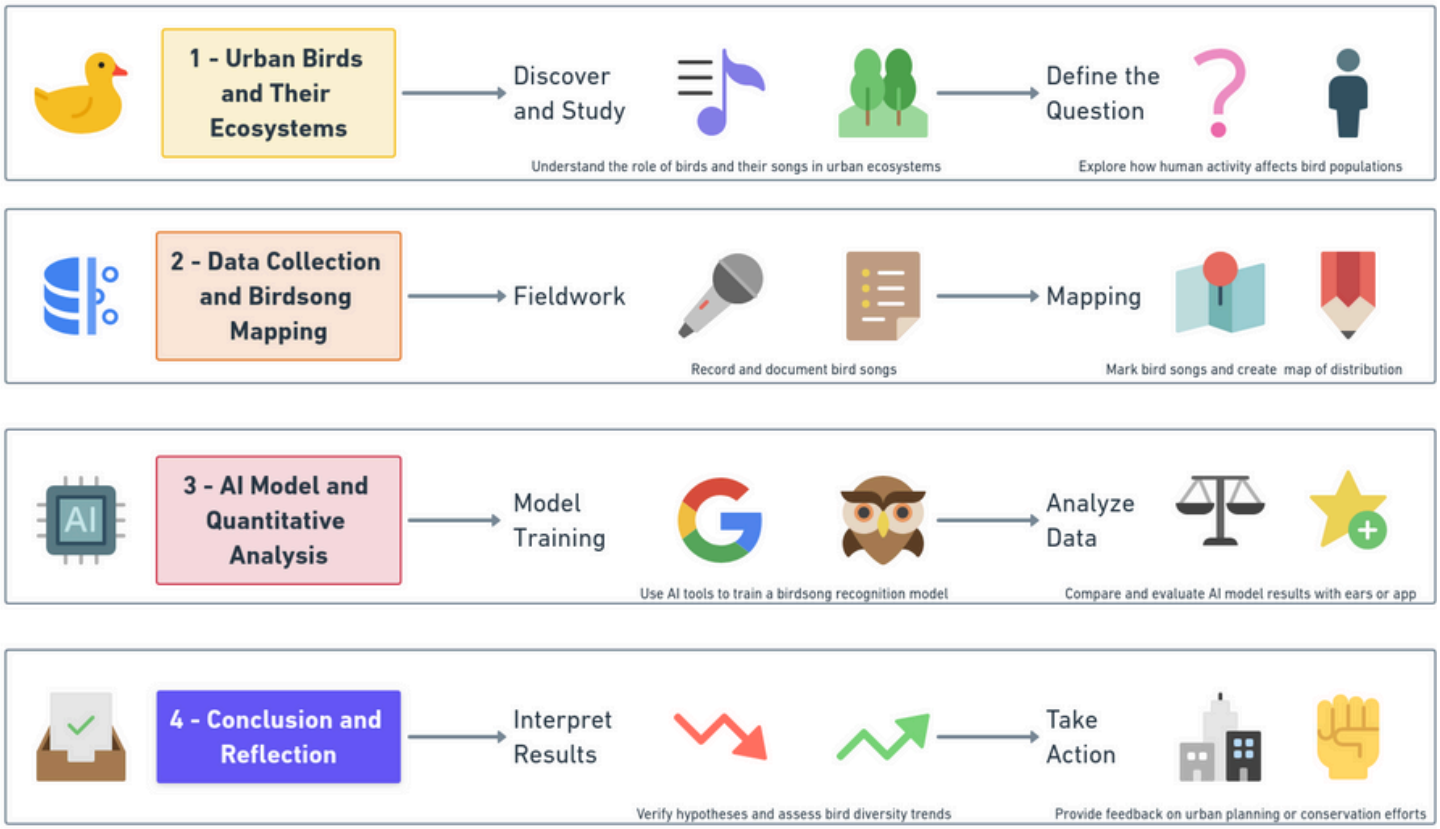
In this activity, we will explore three main topics: 1. the importance of birds, 2. the diversity of species based on birds' songs, and 3. the world of A.I., particularly supervised learning. More into details, the protocol is struture in the following steps:

1. **Understanding Urban Bird Diversity and Their Ecological Roles -** Discuss the significance of birds in urban ecosystems, explore species differentiation, and appreciate the diversity of bird songs in communication.

2. **Playing the Birdsong Identification Game -** Engage in interactive activities where participants match bird songs to species, enhancing auditory and visual memory for bird identification.

3. **Introducing Supervised Learning -** Introduce the concept of supervised learning and its application in bird song recognition.

4. **Collecting, Analysing and Mapping Birdsongs**
    1. Through Field Observation and Data Collection - Conduct a nature walk to observe and record bird sounds, applying the knowledge gained from previous steps.
    2. Through Data Analysis and Model Testing - Analyze collected data using trained models and explore specialized applications for bird identification.
    3. Through the Creation of an Urban Bird Diversity Map - Synthesize collected data to create a visual representation of bird species diversity in explored urban locations.



Getting started

Duration: 180 minutes or 3 lessons

Level of difficulty:

Moderate

Material needed:

- Computers or mobile devices
- Microphones for recording bird sounds
- BirdNET or Merlin Bird ID app/website access
- Notebooks for data recording
- Projector for demonstrations
- OpenStreetMap for geotagging and mapping

Glossary

Keywords & Concepts	Definitions
Urban Biodiversity	The variety of living organisms found in urban environments, including birds, plants, and other wildlife.
Birdsong	Vocalizations produced by birds for communication, territory marking, and mating purposes.
Supervised Learning	A type of machine learning where an algorithm is trained on labeled data to make predictions or classifications.
Ornithology	The scientific study of birds, including their behavior, physiology, and ecology.
Ecological Role	The function or part played by an organism within its ecosystem, such as pollination or seed dispersal for birds.
Geotagging	The process of adding geographical identification metadata to various media such as photographs or audio recordings.
Species Differentiation	The process of distinguishing between different species based on their unique characteristics, such as appearance or vocalizations.
Conservation	The protection, preservation, and careful management of the environment and natural resources.
Artificial Intelligence (AI)	The simulation of human intelligence processes by machines, especially computer systems.
Urban Ecosystem	The ecological system found within an urban environment, including both natural and human-made elements.

Protocol

Step 1 - Exploring Urban Bird Diversity and Their Ecological Roles

Background and description of the problem to be solved in this step: Introduce students to the world of birds, their roles in urban ecosystems, and the importance of preserving avian diversity. Highlight how birds contribute to ecological balance and communicate through songs. Discuss the interconnectedness of urban biodiversity and human well-being, and set the stage for exploring how technology can assist in conservation.

Learning Objectives: Ensure students understand the ecological role of birds, including their impact on ecosystems, their functions as pollinators and seed dispersers, and their role as indicators of environmental health.

Conceptualisation

In this phase, students will define key concepts related to urban birds and the factors influencing their presence in cities. To help them formulate strong hypotheses, clarify fundamental ideas such as urban biodiversity, bird behavior, and human impact on ecosystems. The teacher will guide students in understanding these concepts through discussions and simple definitions.

Next, students will work on generating a specific research question. A research question is a clear, focused inquiry that guides the investigation by identifying what the study aims to discover. It is important to formulate a research question before proposing a hypothesis as it sets the direction for the entire study and ensures that hypotheses are relevant and targeted. Examples of research questions could be:

- **How does human activity affect the presence of birds in urban areas?**
- **What kinds of urban environments are more favorable for bird populations?**
- **How does the presence of green spaces influence bird diversity in cities?**

Once a research question is established, students will collaborate in small groups to brainstorm and explore factors that impact bird populations using books, scientific articles, and online resources. Based on their research, they will formulate hypotheses. A hypothesis is a statement that needs to be verified through experimentation or observation. The goal of a hypothesis is to provide potential answers to the research question. Validating or invalidating a hypothesis can lead to reformulating the research question to either refine or modify it. Even if the question is not fully answered, all hypotheses should help to better frame the potential answer and clarify its limitations.

Examples of hypotheses for the research questions mentioned above could be:

- For the question '**How does human activity affect the presence of birds in urban areas?**', a hypothesis could be 'Areas with high levels of human activity will have significantly fewer bird species compared to quieter, less disturbed areas.'

- For the question '**What kinds of urban environments are more favorable for bird populations?**', a hypothesis might be 'Neighborhoods with more diverse vegetation and tree cover will show a higher density of bird species compared to areas with limited green infrastructure.'

- For the question '**How does the presence of green spaces influence bird diversity in cities?**', a possible hypothesis could be 'Urban parks and naturalized green spaces will support greater bird diversity compared to areas without such spaces.'

Each group will then mark their hypotheses on a map of the study area, using different colors to indicate areas where they expect to see high or low bird activity. This collaborative process will also involve discussions on how to spatialize the study area and choose appropriate locations for data collection.

Additionally, students will be encouraged to apply critical thinking by confronting different points of view during the conceptualization phase. They should consider and debate various factors that may affect bird populations and discuss the most logical choices for their study. This will help them make more informed decisions, weigh evidence, and understand that scientific research often requires balancing competing perspectives.

This step will help students understand not only the importance of hypothesis formulation but also how to effectively map and spatialize their study. By combining theoretical knowledge with practical mapping, they will be better prepared to conduct data collection during the subsequent phases of the experiment.

Students Investigation

In this phase, students will learn how to establish an experimental protocol to validate their hypotheses. The teacher will guide them through the steps necessary to design a rigorous investigation, encouraging systematic and critical thinking about each aspect of the experimental process.

Preliminary Documentary Research.
Before setting up experiments, students will conduct a literature review to identify existing research articles that address similar questions or the same subject of study. This research will help them build a foundational understanding, familiarize themselves with key concepts, and review existing evaluation methods. This preliminary phase will shape the students' approach, ensuring their work is informed by established knowledge.

At the end of the literature review, the teacher will encourage students to share their findings to develop a common vision of the problem. Acting as a facilitator, the teacher will guide the discussion, provide examples, and encourage participation. Visual aids and audio clips will be used to help students understand the topic of bird conservation. The teacher will emphasize the connection between birds and broader environmental health indicators.

The following topics should be discussed to develop the experimental protocol:

- **Bird Significance:** Begin with a discussion highlighting the importance of birds in urban environments. Encourage students to share personal experiences with birds in their neighborhoods. Explore how bird presence impacts urban ecosystems, from plant pollination to pest control.
- **Species Differentiation:** Present images or short video clips of bird species commonly found in urban areas. Guide students in observing features such as beak shapes, feather colors, and sizes that help identify these species. Discuss how these adaptations may help birds thrive in cities.
- **Bird Songs:** Play recordings of bird songs and explain how birds use these vocalizations to communicate, such as marking territory, attracting mates, and signaling danger. Ask students to note the differences between the songs and discuss why different species have distinct calls.

Facilitate a question-and-answer session to reinforce key points about bird diversity and the role of bird songs. This will also help assess students' initial understanding of the subject.

Experimental Protocol Development.
Once the literature review is complete, students will apply their newfound knowledge to design a simple yet rigorous experimental protocol. This protocol will aim to evaluate the impact of bird diversity on human life, following the scientific method through these key steps:

- **Formulating a Clear Research Question**: Define the study's aim regarding urban bird populations.
- **Elaborating a Testable Hypothesis**: Propose a hypothesis that can be experimentally verified.
- **Designing Observational Protocols**: Determine the methodology for observations, specifying locations and times for bird identification (visual and auditory), environmental conditions to monitor, and the length of each observation period.
- **Data Collection**: Specify the data to be gathered, including the number and types of bird species observed at each location and any recorded bird songs.

- **Data Analysis**: Outline a systematic approach to analyze the collected data, incorporating simple statistical tools or mapping software to visualize bird species distribution across different areas.
- **Interpretation and Evaluation**: Detail how to interpret the results to assess the initial hypothesis, such as comparing bird presence in areas with varying levels of human activity.
- **Sharing Results**: Develop a plan to present findings and conclusions to the class or a broader audience through presentations or reports.

Students will collaborate in small groups to develop their experimental protocols, taking into account their chosen locations and hypotheses. The teacher will guide discussions to ensure the protocols are feasible and scientifically sound. Groups will use tools such as maps, literature review notes, and brainstorming sessions to refine protocol details.

Tips for Teachers: An active learning approach allows students to design protocols independently. However, the teacher plays a crucial role as a guide, adopting a semi-directed approach to ensure the final protocol includes essential study components: visual and auditory identification techniques, regular data recording, and an emphasis on both quantitative and qualitative observations. This approach maintains scientific rigor while fostering students' autonomy and creativity in their investigative process.

Example of Protocol

1. **Study Objective**: Examine the impact of urban environments on bird diversity by investigating whether areas with high human activity have fewer bird species compared to less disturbed areas.
2. **Hypothesis**: Areas with high human activity will have significantly fewer bird species than quieter, less disturbed areas.
3. **Study Duration**: Two weeks, with data collected twice-weekly in mornings and evenings.
4. **Data Collection Method**:
   - **Visual and Auditory Observations**: Conduct bird surveys at selected locations (e.g., parks, busy streets, residential neighborhoods). Record the number and types of bird species observed and any bird songs heard during each session.
   - **Environmental Observations**: Record relevant environmental factors, including vegetation type, noise levels (using a decibel meter if available), temperature, and the presence of water sources or feeding stations.
   - **Human Activity Levels**: Observe and note human activity levels (e.g., pedestrian and vehicle traffic, other disturbances) during each data collection session.
5. **Data Usage**:
   - **Data Storage**: Store quantitative data (bird counts) in a CSV file, including date, time, location, and environmental conditions.
   - **Data Analysis**: Calculate averages and medians for bird counts across locations. Create graphs to visualize bird presence in relation to human activity levels and other environmental factors. Identify trends and discuss notable differences.
   - **Comparison of Factors**: Visually compare bird presence with noise levels, vegetation types, and other recorded factors. Use simple graphs to highlight general trends between bird numbers and these indicators. Discuss any deviations from these trends.
   - **Correlation Analysis**: Calculate correlation coefficients between human activity levels and bird presence. Interpret these coefficients to determine the strength of the relationship between human activity and bird numbers. Discuss which factors may be most influential.
6. **Presentation of Results**: Present findings using graphs that show the correlation between human activity and bird presence. Document the entire protocol in an infographic for sharing with the class, school, or on social media.

At the end of this step, students will have a well-developed experimental protocol that they can use to conduct their investigation. This structured approach will give them the tools to explore the impact of human activity on birds methodically and rigorously. The teacher will act as a facilitator, guiding the discussion, providing examples, and

encouraging participation. Use visual aids and audio clips to help students understand the topic of bird conservation. Emphasize the connection between birds and broader environmental health indicators.

Conclusion & Further Reflexion

- **Knowledge Acquired**: By the end of this phase, students will have gained a deeper understanding of the factors influencing bird populations in urban areas. They'll recognize how urban environments, green spaces, and human activities shape bird diversity. Students will also appreciate the importance of visual and auditory identification methods in collecting reliable scientific data.
- **Classroom Implementation Insights**: Students will have learned to conduct literature reviews, engage in collaborative discussions, and create structured observational protocols. This phase highlights the importance of teamwork, systematic data collection, and critical thinking. By applying these skills in a practical context, students will better understand scientific processes and urban ecology's relevance.
- **Key Learning Outcomes**: Students will develop skills in formulating research questions, designing observational studies, and analyzing data. They'll enhance their ability to evaluate environmental factors affecting bird populations and refine their scientific communication skills. These activities will foster an appreciation for biodiversity, helping students connect local observations with broader conservation challenges.

To conclude this phase, students can participate in an open-ended discussion to reflect on the study's broader implications. Some thought-provoking questions include:

- How do various human activities and additional environmental factors differently impact bird populations and presence?
- Which urban environments are most supportive of bird populations, and how do seasonal changes affect urban bird species presence?
- What can local communities do to create bird-friendly urban areas, and how does urban biodiversity relate to overall ecosystem health?
- Can minor changes in urban planning significantly impact bird diversity and survival, and what challenges do researchers face when studying urban birds?
- How can our data inform urban planning and bird conservation policies, and how might climate change affect bird populations along with existing mitigation strategies?

These discussions will help students synthesize their learning, critically evaluate their findings, and consider broader conservation efforts. By contemplating the implications of their research, students will better grasp biodiversity's importance and urban planning's role in shaping sustainable environments.

Step 2 - Playing the Birdsong Identification Game

Background and description of the problem to be solved in this step: The purpose of this step is to train students to recognize the bird songs of urban species through an interactive quiz game. The objective is to enhance students' auditory and visual memory, which will help them during the future observation campaign on bird species diversity in urban environments. By engaging in this activity, students will become familiar with a variety of bird songs and learn to differentiate between species based on vocalizations and visual cues. This step also serves as an introduction to supervised learning concepts, laying the foundation for automated bird sound recognition in later steps.

Learning Objectives: Enhance birdsong identification capability, foster observation skills, and provide an initial introduction to the concept of supervised learning.

Conceptualisation

In this phase, students will identify the unique features of bird songs that distinguish one species from another. Start by having students listen to recordings of different bird species multiple times, encouraging them to discuss the specific characteristics of each bird song collectively. This collaborative discussion will highlight patterns such as pitch, repetition, and rhythm (key elements in identification). Next, challenge students to hypothesize how they can recognize bird species based solely on sound or visual cues. Prompt them to consider specific features that aid recognition, like a song's pitch or distinctive visual traits such as feather patterns. Introduce the concept that machines, like humans, can be trained to recognize these patterns through supervised learning (a topic they'll explore in subsequent activities).

To help in the identification process, students will be introduced to the most common bird species found in European urban environments :

Rock Dove
Columba livia
https://www.oiseaux.net/birds/rock.dove.html

House Sparrow
Passer domesticus
https://www.oiseaux.net/birds/house.sparrow.html

Great Tit
Streptopelia decaocto
https://www.oiseaux.net/birds/great.tit.html

Eurasian Collared Dove
Streptopelia decaocto
https://www.oiseaux.net/birds/eurasian.collared.dove.html

Carrion Crow
Corvus corone
https://www.oiseaux.net/birds/carrion.crow.html

Common Starling
Sturnus vulgaris
https://www.oiseaux.net/birds/common.starling.html

European Robin
Erithacus rubecula
https://www.oiseaux.net/birds/european.robin.html

Common Blackbird
Turdus merula
https://www.oiseaux.net/birds/common.blackbird.html

Eurasian Blue Tit
Cyanistes caeruleus
https://www.oiseaux.net/birds/eurasian.blue.tit.html

Western House Martin
Delichon urbicum
https://www.oiseaux.net/birds/western.house.martin.html

These species are commonly seen in urban environments and provide a good foundation for the bird identification exercises in this activity. Students should familiarize themselves with these species as part of their preliminary learning.

Students Investigation

The investigation of this stage include three steps.

Step 1 - Listening and Discussion: Students will **examine photos of various urban bird species and listen to their songs**, noting distinctive visual and auditory features. Play recordings of several urban bird species, allowing students to listen multiple times. Facilitate a discussion where they describe and note each bird song's particularities. Encourage attention to specific features such as tone, rhythm, pitch, and distinctive notes. This builds a shared understanding of urban birds' vocal diversity.

Step 2 - Birdsong Quiz Game: After the listening phase, conduct a quiz to test recognition skills. The quiz includes two question types:

- **Audio-Based Questions:** Students identify species from bird songs, reinforcing auditory memory and the ability to differentiate similar-sounding species.
- **Visual-Based Questions:** Students match bird pictures or names to correct songs from multiple sound clips, linking visual information with auditory characteristics.

Step 3 - Teamwork and Feedback: Organize students into small teams for collaborative quiz participation. Provide immediate feedback after each question, replaying the correct bird song and highlighting its distinguishing features. This feedback loop reinforces learning and helps correct misconceptions.

This investigation engages students with visual and auditory information to identify common urban bird species. It highlights the complexity of recognizing bird songs, emphasizing humans' difficulty in memorizing and accurately identifying a wide repertoire of bird vocalizations.

This challenge underscores the potential value of technology, such as AI tools, in aiding identification and supporting conservation efforts. By understanding these limitations, students appreciate the importance of practice, repetition, and complementary technological tools in biodiversity studies.

Conclusion & Further Reflexion

- **Knowledge Acquired**: By the end of this phase, students will have gained a deeper understanding of bird songs and the ability to distinguish between various urban bird species. They will have honed their auditory and visual recognition skills, developing techniques to identify bird songs and features. Students will also recognize the challenges in mastering a large repertoire of bird vocalizations, highlighting technology's supportive role in this process.
- **Classroom Implementation Insights**: Students will have engaged in both individual and collaborative learning through listening exercises and quiz games. This phase underscores the importance of repeated exposure, discussion, and teamwork in reinforcing learning. By applying these skills in a structured context, students gain practical insights into pattern recognition, both manually and through AI applications.
- **Key Learning Outcomes**: Students will enhance their ability to recognize and differentiate bird songs and visual features. They'll grasp the parallels between human learning processes and machine learning, particularly how practice and repetition are crucial in both. The activity fosters an appreciation for the complexity of identifying numerous bird species by sound alone, emphasizing the value of technological aids in conservation efforts.

To conclude this phase, engage students in a discussion about the broader challenges of bird song identification and biodiversity monitoring. Consider the following questions:

- How does the intricacy of bird songs challenge human memory and identification capabilities?
- What techniques can we employ to enhance our recognition of bird vocalizations?
- In what ways can AI tools complement human abilities in areas where memory and pattern recognition are limited?
- What are the advantages and drawbacks of using technology for bird identification compared to human expertise?

These discussions will help students synthesize their learning, recognize the limitations of human auditory memory, and appreciate AI's complementary role in supporting biodiversity conservation efforts.

Tips for Teachers: You can play this video (https://www.youtube.com/watch?v=R9OHn5ZF4Uo) to help students better understand AI and how it learns. This engaging and informative video provides a clear explanation of machine learning concepts, illustrating how AI systems process data to recognize patterns and make predictions. By watching this video, students will gain insights into the fundamental principles behind AI, which will enhance their understanding of the supervised learning activities they are about to undertake. The video's visual representations and examples will help solidify the connection between human learning processes and machine learning algorithms, preparing students for the hands-on experience with Google Teachable Machine in the next step.

Step 3 - Introducing Supervised Learning - Building an AI Birdsong Recognition Model

Background and description of the problem to be solved in this step: Introduce supervised learning through hands-on experience with Google Teachable Machine. Students will grasp the fundamentals of machine learning and understand how computers can be trained to recognize bird songs. This step builds upon the manual identification techniques learned earlier.

Learning Objectives: Comprehend the core concepts of supervised learning. Master the process of training a machine learning model using labeled audio data. Analyze the similarities and differences between human and AI-based pattern recognition. Gain proficiency in using Google Teachable Machine for bird song recognition. Evaluate the potential and limitations of AI in biodiversity conservation efforts.

Conceptualisation

In this phase, students will discover the concepts of supervised learning, with a specific focus on AI-based bird song recognition. Before engaging with Google Teachable Machine, it is crucial for students to understand the following key concepts:

1. **Supervised Learning:** This fundamental aspect of machine learning involves training an algorithm using a labeled dataset. The model learns to connect inputs (like bird songs) with outputs (such as bird species). This process is similar to how students learn by seeing examples repeatedly.

2. **Training Data:** This refers to the examples used to train the model. In our bird song activity, the training data includes bird songs labeled with their species. It's important for students to understand that the variety and quality of this data affect how well the model works. They should think about how diverse their training data should be for a strong model.

3. **Labels (or class):** These are the correct answers provided during training. Each bird song in our dataset has a label that shows its species. It's crucial to have accurate labels because mistakes can hurt the model's performance. Discuss the issues that can arise from incorrect labels and how to ensure they are correct in real situations.

4. **Model Accuracy:** This measure shows how often the AI correctly identifies a bird species based on its song. Help students recognize that accuracy is affected by factors like the amount and quality of training data and the complexity of the songs. They will evaluate their models by testing them on new data. Encourage them to think about what might influence accuracy and how they could improve it.

5. **Human vs. Machine Learning:** Compare how humans and machines learn to identify bird songs. Humans use context, experience, and intuition, while machines rely on data patterns. Encourage students to think about situations where each method might work better or face challenges. This comparison will enhance their understanding of the strengths and limitations of AI in real-world scenarios.

Once these concepts are introduced, guide students in formulating an hypothesis regarding the **effectiveness of machine learning compared to manual identification**. Encourage students to consider what factors might influence the performance of AI models, such as the quality and quantity of training data, background noise in recordings, and the diversity of bird songs in urban areas.

Ask students to hypothesize scenarios in which AI might outperform human identification, such as in consistently recognizing a large dataset of bird songs, or situations where humans might be more accurate due to their ability to

understand context and nuances.

The goal is to foster an understanding of both the potential and limitations of AI in pattern recognition, particularly in ecological studies.

Tips for Teachers: Guide students through the conceptualization phase, explaining the principles of supervised learning and highlighting the collaborative nature of the learning process between students and AI systems.

Students Investigation

In this phase, students will create a **machine learning model to recognize different bird species** based on their songs. This guide outlines the process of data collection, model training, testing, and evaluation :

Select Bird Species.
Choose five bird species from the provided list of common urban birds. These will serve as labels for the supervised learning model.

Collect Data from Xeno-canto.
Use the Xeno-canto (https://xeno-canto.org) database to gather audio recordings of songs for each selected species. Create a diverse dataset with multiple examples per species to improve model generalization.

Create Model Using Google Teachable Machine.
Visit Google Teachable Machine (https://teachablemachine.withgoogle.com/train/audio) and follow these steps:

- Upload Training Data: Start a new audio project and upload the collected bird songs. Label each audio file with its corresponding species.
- Train the Model: Provide the labeled data to train the model. Explain to students how the model learns to associate audio inputs with labels, identifying species-specific patterns.
- Adjust Settings: If needed, modify training settings, such as increasing training iterations for improved accuracy.

Test the Model.
Use new, unseen bird songs to test the trained model. Evaluate its ability to generalize and record its performance, noting any errors.

Analyze Limitations and Define Metrics.
Discuss the model's limitations with students. Introduce **precision** and **recall** to quantify model quality:

- Precision: The ratio of correct positive predictions to total positive predictions. This shows the model's accuracy when predicting a specific bird species.
- Recall: The ratio of correct positive predictions to all actual positives. This measures the model's ability to identify all instances of a bird species. Guide students in calculating these metrics to understand the model's strengths and weaknesses.

Reflect and Conclude.
Discuss the model creation process, highlighting successes and challenges. Emphasize the **importance of high-quality data and the difficulties AI faces in learning complex patterns** like bird songs.
Illustrate how AI can aid **conservation efforts** by facilitating bird species identification in large datasets.

Conclusion & Further Reflexion

- **Knowledge Mobilized**: At the end of this phase, students will have gained a deeper understanding of how supervised learning models work and how they can be used to recognize bird songs. They will have learned to collect, label, and use training data to teach an AI model. Students will also appreciate the similarities and differences between human pattern recognition and machine learning.
- **Classroom Implementation Reflection**: Students will have engaged in creating and training a machine learning model, testing it with new data, and reflecting on its performance. They will have learned about the importance of training data quality, labeling accuracy, and evaluation metrics such as precision and recall. This step emphasizes the value of systematic data handling, critical thinking in evaluating AI performance, and understanding the limitations of machine learning.
- **General Learning Outcomes**: Students will develop skills in data collection, data labeling, and using AI tools like Google Teachable Machine. They will improve their understanding of key AI concepts, such as supervised learning, precision, and recall. The activity will also foster an appreciation of the strengths and limitations of AI in biodiversity research and its potential role in conservation.

To conclude this phase, engage students in an open-ended discussion to reflect on the broader implications of using AI for biodiversity monitoring. Possible questions for discussion include:

- How does the quality of training data affect the accuracy of an AI model?
- In what situations might AI outperform human experts in recognizing bird songs, and when might humans be better?
- How do metrics like precision and recall help in evaluating an AI model?
- What are the potential uses of AI in conservation efforts, and what are its limitations?
- How can AI tools complement human efforts in understanding and protecting biodiversity?

These discussions will help students synthesize what they have learned, understand the limitations of machine learning, and appreciate the complementary role that AI can play alongside human expertise in supporting biodiversity conservation.

Step 4 - Collecting, Analysing and Mapping Birdsongs

Background and description of the problem to be solved in this step: Students will collect bird songs during a nature walk, analyze these recordings using the AI models they previously created, and synthesize their findings by creating a visual bird map. The objective is to validate the hypotheses formulated in Step 1 by connecting theoretical learning with field observations, data analysis, and visualization. This integrated activity combines outdoor exploration, data analysis, and mapping to foster a deeper understanding of bird diversity in urban areas.

Learning Objectives: Develop practical skills in field data collection and bird song recording. Apply AI models to real-world data and understand the challenges of bird species identification. Learn to map and visualize bird species distribution using geospatial tools. Reflect on the impact of urban features on biodiversity and bird distribution. Foster a critical understanding of how technology and field research can be integrated to support conservation efforts.

Conceptualisation

During this phase, students will explore several essential concepts vital for grasping field research, data analysis, and the impact of technology on the study of urban bird populations. These concepts encompass:

1. **Field Research**: Introduce students to the importance of primary data collection. Discuss how direct observation and audio recording provide raw data that is essential for studying biodiversity in urban settings. Highlight the role of systematic recording (location, environmental context) to ensure high-quality data.

2. **Urban Ecology**: Guide students in understanding how urban features—such as parks, green spaces, building density, and noise levels—affect bird diversity and distribution. Encourage students to think critically about the impact of urban development on bird habitats.

3. **Data Analysis**: Explain the concept of data analysis in the context of ecology. Discuss how analyzing recorded bird songs with AI tools allows us to extract meaningful patterns that might not be obvious through human observation alone. This will set the stage for understanding how AI can assist in biodiversity research.

4. **Hypothesis Formulation**: Ask students to hypothesize about the types of birds they might encounter and the locations they are likely to find them. Encourage them to predict how different urban elements may impact where specific bird species are found or heard. This exercise helps students practice the scientific method, beginning with observation and leading to testable hypotheses.

5. **Mapping as a Visualization Tool**: Discuss the importance of visualizing data through mapping. Explain that creating maps from collected data helps in identifying trends and patterns in bird distribution across different parts of an urban environment. Mapping data also provides an intuitive way to communicate research findings.

By understanding these concepts, students will be better prepared to carry out their investigation, collect relevant data, and draw meaningful conclusions about bird species diversity in urban areas.

Students Investigation

Engage students in **hands-on activities to collect, analyze, and visualize bird data**. This practical approach allows them to apply their knowledge of AI and bird identification in real-world scenarios. The investigation consists of three main steps:

Nature Walk & Sound Collection.
Students will record bird songs during an outdoor exploration using microphones. Encourage them to note down the context of each recording, such as location, nearby vegetation, noise levels, and weather conditions. These notes will provide essential background information for understanding bird presence in different urban environments.

Data Analysis with AI Models.
Once back in the classroom, students will use their trained AI models to identify the bird species from the collected recordings. They will also compare the results with those from specialized bird identification apps like BirdNET or Merlin Bird ID to evaluate the accuracy of their models and cross-check species identifications.

Mapping Observations.
After identifying the bird species, students will geotag each of their recordings using Google My Maps. They will add photos, species information, and recordings to create a comprehensive map that visually represents bird diversity and distribution in the urban area they explored. This visual tool helps to correlate the spatial distribution of bird species with different urban features.

By following these steps, students will gain practical experience in field research, data analysis, and visualization techniques. This investigation phase will help them better understand the challenges and opportunities in using AI for biodiversity monitoring and conservation efforts in urban environments.

Tips for Teachers on Classroom Implementation: To effectively organize this session with students and maximize their earning outcomes, consider dividing the students into **three specialized groups** to provide a more comprehensive understanding of bird identification methods:

1. Group 1 - Technology-Assisted Identification
   This group will capture bird sounds using their smartphones and employ the AI model developed in Step 3 to recognize species. This approach allows students to directly apply and evaluate the effectiveness of their machine learning model in real-world conditions.

2. Group 2 - Traditional Identification
   These students will rely solely on their knowledge acquired in Step 2, performing bird recognition without technological aid. This method challenges students to apply their learned skills and tests the effectiveness of traditional bird identification techniques.

3. Group 3 - Professional App-Based Identification
   This group will utilize the Merlin Bird ID application for species recognition. By using a professional tool, students can benchmark their findings against a more comprehensive database and explore advanced identification features.

As the activity progresses, it is anticipated that the limitations of the Teachable Machine model will become visible when compared to human identification methods.

While the dedicated Merlin Bird ID application is expected to demonstrate a broader recognition capacity, it may also encounter challenges in field conditions, such as ambient noise interference.

This multi-faceted, group-based approach offers an opportunity for **comparative analysis**. Students can engage in discussions about the **quality and reliability of different experimental data collection methods**.

Furthermore, it brings the possibility to explore how these datasets might be cross-referenced and integrated to create a more comprehensive and qualitative understanding of local bird populations.

Conclusion & Further Reflexion

- **Knowledge Mobilized**: By the end of this step, students will have experienced the entire process of collecting, analyzing, and visualizing field data. They will understand the importance of data quality, learn how to apply AI models in real-world scenarios, and appreciate how mapping can be used to explore ecological patterns. The skills learned here are foundational for ecological fieldwork and data-driven decision-making.
- **Classroom Implementation Reflection**: Students will have conducted fieldwork, tested their AI models, and collaborated to create a visual representation of their findings. This phase emphasizes the iterative nature of scientific investigation—from data collection to analysis and interpretation. Students will reflect on how urban environments shape bird distributions and the potential biases in their recordings and model predictions.
- **General Learning Outcomes**: Students will develop skills in primary data collection, the practical application of machine learning models, and the creation of spatial visualizations. They will also gain an understanding of the complex interactions between urban features and bird species distribution. The activity fosters a critical perspective on the use of AI and geospatial tools in understanding urban biodiversity and emphasizes the value of such tools in conservation efforts.

To conclude this phase, engage students in an open-ended discussion about their findings and the implications for urban biodiversity conservation. Possible questions include:

- What did you learn about the distribution of birds in different parts of the city?
- How accurate was your AI model compared to specialized identification apps?
- What challenges did you face during data collection, analysis, or mapping?
- How might urban planning and green space development affect the distribution of bird species?
- How can the visual map created during this activity support local conservation efforts?

These discussions will help students synthesize their findings, reflect on the entire investigative process, and understand the broader applications of their work in ecological research and urban planning.

Exploring other initiatives

Citizen Science Projects

eBird

A global bird-monitoring platform by the Cornell Lab of Ornithology where citizens record and share bird sightings. Students can analyze local data trends and compare them with global patterns to understand urban biodiversity.

https://ebird.org/home

Zooniverse's Bird Spotting Projects

Projects like "Penguin Watch" or "Chirp!" use crowd-sourced data to identify bird species from photos or audio recordings. These platforms emphasize the power of collective efforts in monitoring biodiversity.

https://www.zooniverse.org

Technology-Driven Conservation

BirdNET

An AI-based app for identifying bird species through their songs. Students can use it to explore how AI is applied in conservation and compare its performance with other methods.

https://birdnet.cornell.edu

Bioacoustic Monitoring Stations

Permanent or mobile setups with microphones and AI tools to automatically record and analyze bird vocalizations. Students can explore how this data informs urban planning and conservation.

https://carbonrewild.com/bioacoustic-monitoring/

Policy and Community Initiatives

Urban Bird Treaty Cities

A U.S. initiative supporting bird-friendly practices in cities. Students can research policies implemented in these cities and suggest adaptations for their local context.

https://www.fws.gov/program/urban-bird-treaty

Bird-Safe Building Initiatives

Programs that encourage architectural modifications to prevent bird collisions with windows. Examples include NYC's Local Law 15 or Toronto's "Bird-Friendly Guidelines."

https://bit.ly/BirdFriendlyGuidelines

Online Platforms and Databases - Bird Identification & Machine Learning

- **World Birds**
  A comprehensive global database featuring detailed information about bird species, their habitats, migration patterns, and conservation status. Includes interactive maps and community contributions.

  🔗 https://www.worldbirds.org

- **BirdNET by Cornell Lab**
  An advanced AI-powered system for bird sound identification. Uses deep learning algorithms to analyze audio recordings and identify bird species with high accuracy.

  🔗 https://birdnet.cornell.edu

- **Google's Teachable Machine**
  A user-friendly platform for creating custom machine learning models without coding. Perfect for developing bird identification projects using visual or audio recognition.

  🔗 https://teachablemachine.withgoogle.com

- **Merlin Bird ID by Cornell Lab of Ornithology**
  A sophisticated bird identification app combining visual recognition, sound ID, and traditional field guide features. Includes regional bird packs and seasonal information.

  🔗 https://merlin.allaboutbirds.org

- **Xeno-canto Regional Bird Sounds**
  The world's largest collaborative database of bird recordings. Features over 800,000 recordings of bird sounds from around the globe, with detailed metadata and community annotations.

  🔗 https://xeno-canto.org/explore/region

Appendix: Printable Identification Sheet

Birds Songs

Write the corresponding bird to each song.

Song 1	**Song 2**	**Song 3**	**Song 4**
Song 5	**Song 6**	**Song 7**	**Song 8**
Song 9	**Song 10**	**Song 11**	**Song 12**
Song 13	**Song 14**	**Song 15**	**Song 16**