

About Moveduck

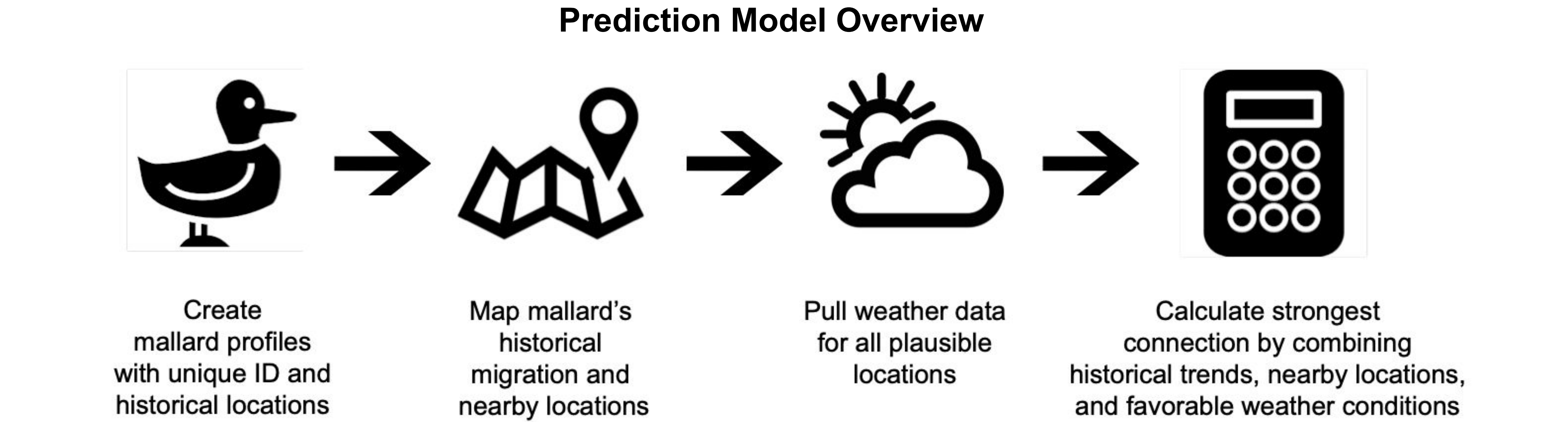
The Mallard Migratory application is a data-driven platform that analyzes and visualizes duck migration across the Mississippi Flyway. Using historical flight data, real-time weather, and flock counts from the Tennessee Technological University Department of Biology mallard database, it applies predictive algorithms to forecast future migration routes. The tool serves as a centralized resource for researchers and conservationists seeking clear, actionable insights into mallard behavior.

Objective

To deliver the first all-in-one duck migration intelligence platform tailored for the Mississippi Flyway—combining GPS tracking, historical data, and predictive algorithms into one sleek, interactive tool. Our goal is to transform scattered, outdated migration tracking into real-time, high-accuracy insights that empower researchers and conservationists alike. Presenting clear, data-backed forecasts that show where the ducks are and where they are traveling to next.

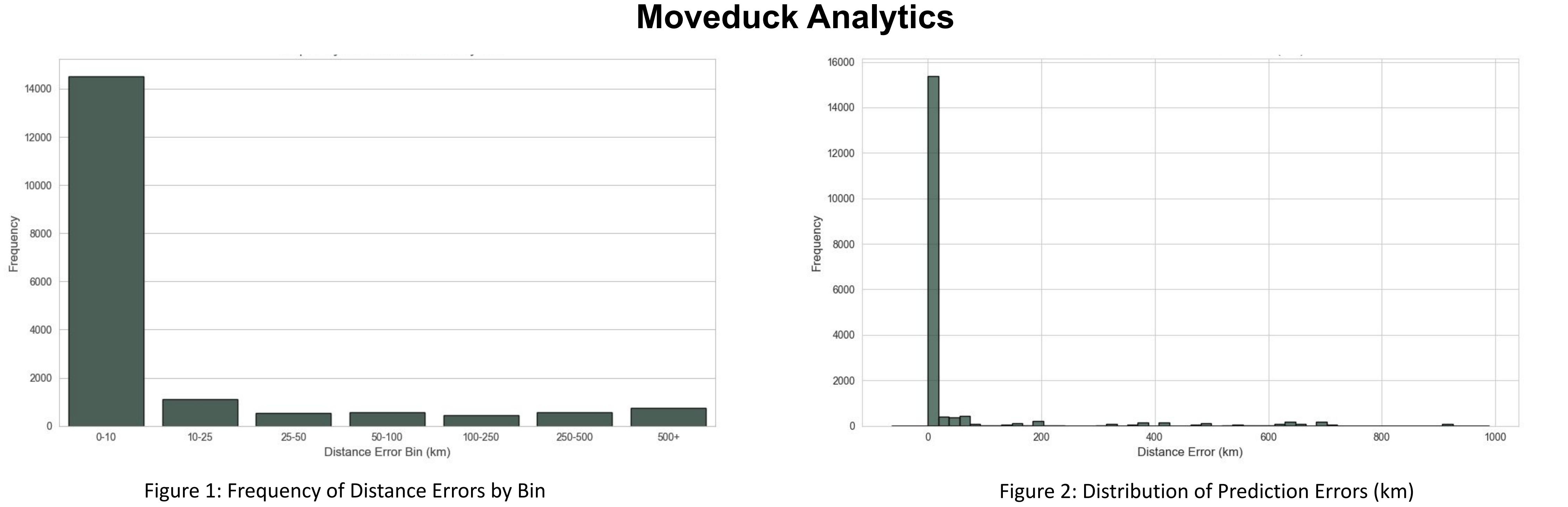
- Frontend Features**
- Our platform leverages React and Leaflet to deliver a dynamic, open-source solution featuring:
- **Dynamic Heatmap Visualization:** Clearly see the area where mallards are departing from and their forecasted movements for the next day.
 - **Location Search:** Users can easily input their local area to view personalized migration insights.
 - **Interactive Time Slider:** Users can effortlessly navigate through dates to pinpoint exactly when mallards will be near.

- Backend Capabilities**
- Our system automates the full lifecycle of duck migration prediction, from data ingestion to live deployment:
- **High Performance Computing (HPC):** Utilized to run the custom-built Graph Neural Network (GNN) designed for accurate migration forecasting.
 - **Automated Data Retrieval:** Pulls curated tracking data from Movebank (provided by TTU Wildlife) using predefined parameters.
 - **Graph Neural Network (GNN) Prediction Generation:** Predicts duck movements 7 days ahead using processed data.
 - **GitPages Integration & Deployment:** A script pushes forecasts via GitHub Pages, triggering GitHub Actions to redeploy updated predictions.
 - **Client-Friendly Automation:** The entire backend requires no manual input, keeping the live site consistently up to date.



Prediction Model Functionality

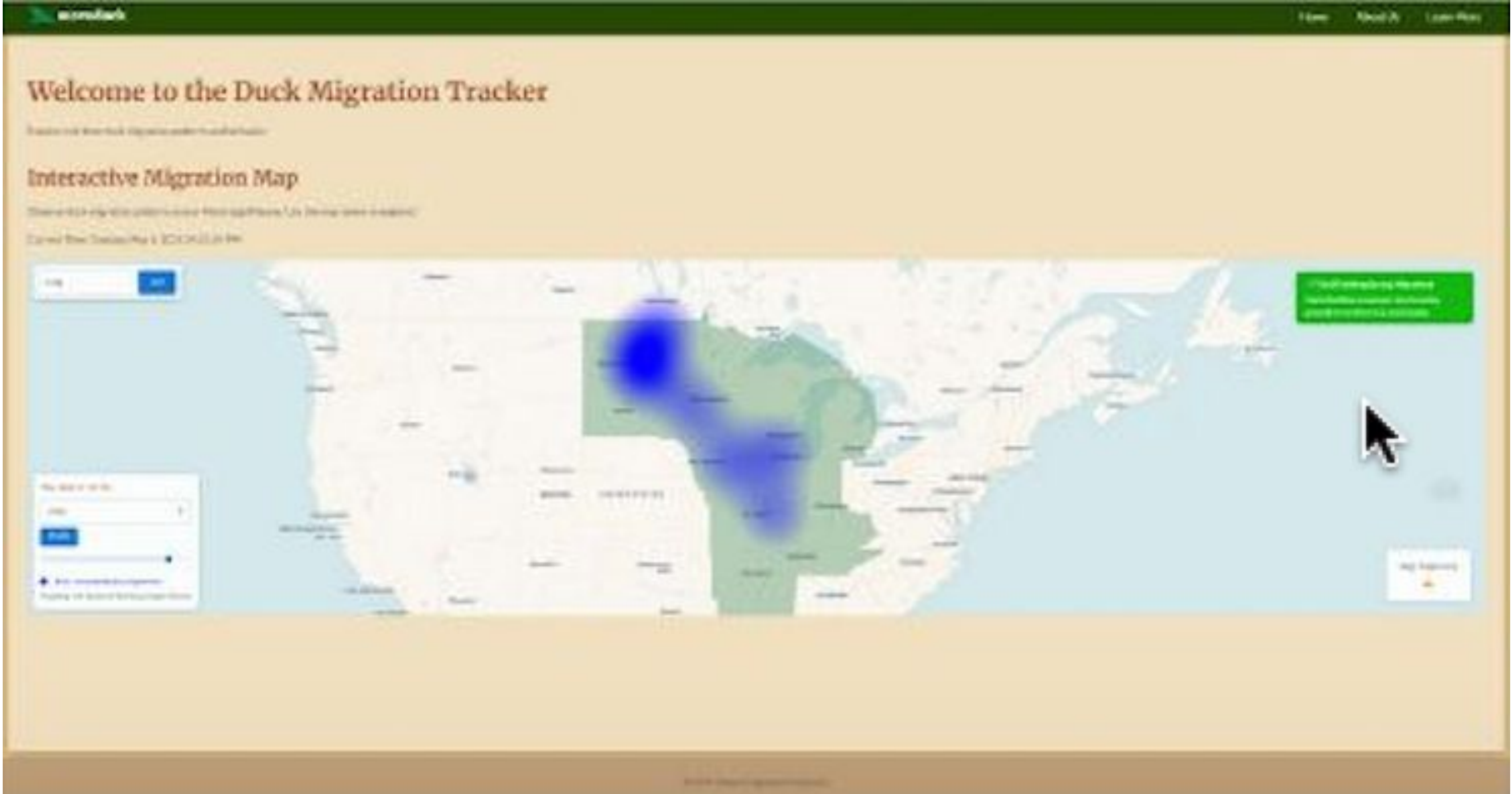
Our custom **Graph Neural Network (GNN)** models duck migration as a dynamic, weighted graph, **leveraging historical data, spatial proximity, and environmental conditions** to forecast future movements. The model builds individual profiles for each duck using **timestamped GPS data**, constructs **nodes for historical stopovers**, adds both **sequential and proximity-based edges with weighted priorities**, and **generates predictions** by evaluating the **most probable next location** based on **migration patterns** and **current weather data**.



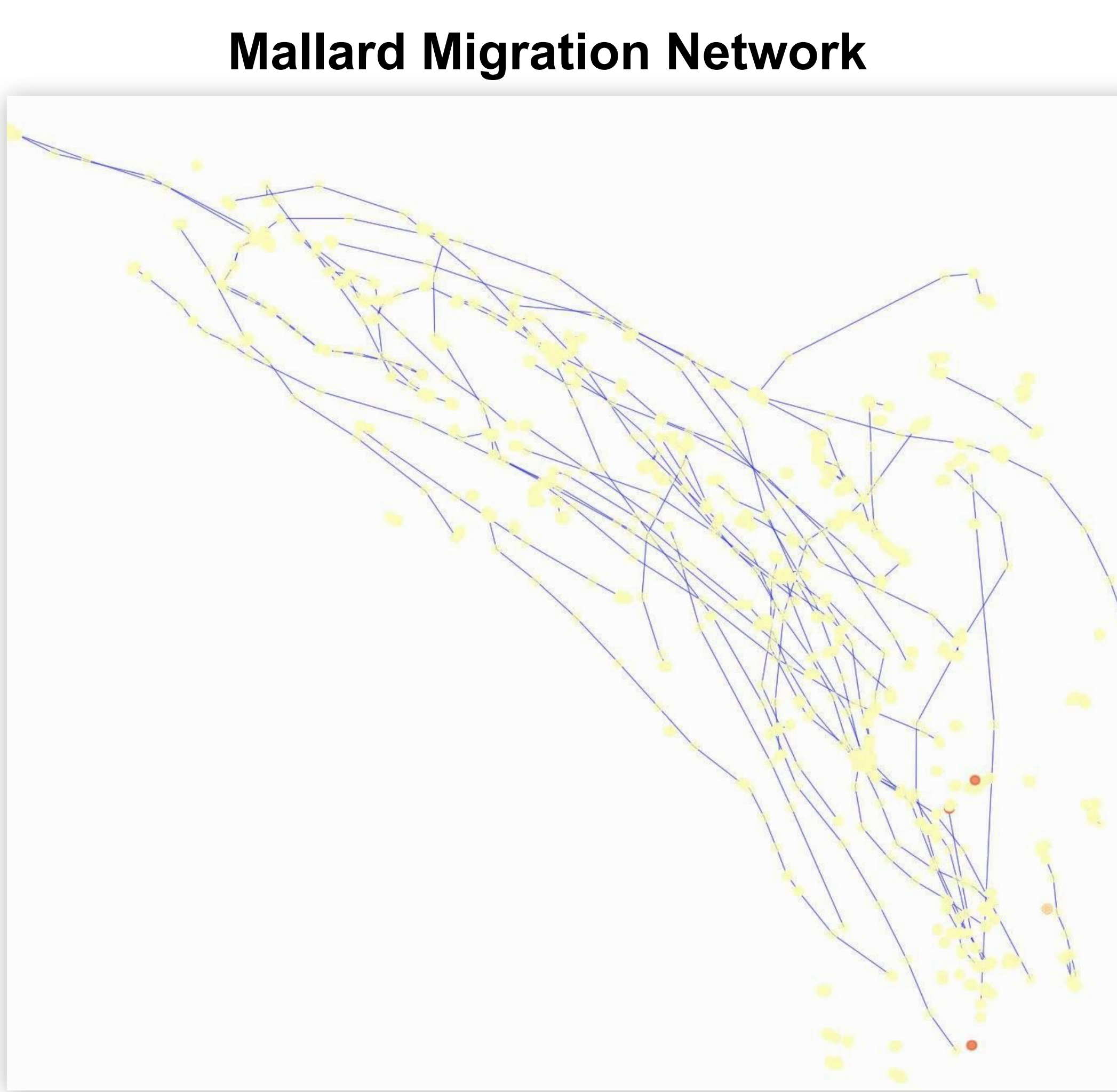
90% of Predictions Within 10 km: The majority of prediction errors fall within the 0–10 km range, demonstrating the model's **high precision** in forecasting migration paths.

Low Error Despite Natural Variability: Ducks exhibit unpredictable behaviors influenced by environmental factors and instinctual shifts. Despite this, the GNN maintains over 90% accuracy, even **accounting for outlier behavior**.

Consistent Performance Across Binned Ranges: The binned distribution emphasizes that even among larger error categories (50 km+), the model's error frequency remains low, reflecting its **stability and reliability across scenarios**.



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This migration network visualization demonstrates the **high fidelity and functional precision** of the tracking system:

- **Accurate Telemetry:** The dense distribution of *yellow* nodes shows fine-grained GPS tracking, confirming the product's ability to capture detailed migratory behavior.
- **Behavioral Insights:** *Orange* and *red* nodes reflect differentiated stopover frequencies, enabling meaningful behavioral classification and trend detection.
- **Route Mapping:** *Blue* edges illustrate clear and coherent migration paths, validating the system's ability to reconstruct real-world travel routes with spatial and temporal accuracy.
- **Network Intelligence:** The structure forms a well-defined graph model, allowing for advanced analysis such as route optimization and identification of critical migratory corridors.

Learn More About the Research

Dr. Bradley Cohen's Wildlife Lab:
<https://www.cohenwildlifelab.com>

Moveduck Website: <https://www.moveduck.com>

Acknowledgements

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