Demonstration of Pishgu: Universal Path Prediction Network Architecture for Real-time Cyber-physical Edge Systems

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ABSTRACT

Pishgu is a universal lightweight network architecture for path prediction in Cyber-Physical Systems (CPS) applications, adaptable to multiple subjects, perspectives, and scenes. Our proposed architecture captures inter-dependencies within the subjects in each frame using Graph Isomorphism Networks and attention. In our demonstration, we will show how Pishgu can predict trajectories for pedestrians and vehicles in different real-world scenarios. We will use video data from various sources, such as surveillance cameras, drones, etc., to illustrate the diversity of subjects, perspectives, and scenes that Pishgu can handle. The goal of our demonstration is to showcase the adaptability and robustness of Pishgu in various CPS applications. We will highlight how Pishgu can capture inter-dependencies within the subjects in each frame using Graph Isomorphism Networks (GINs) and attention mechanisms. We will also compare Pishgu with existing solutions on different metrics such as ADE and FDE. We hope that our demonstration will inspire attendees to explore new possibilities for path prediction in CPS applications using Pishgu. In addition, the demonstration will also consist of a poster to highlight the main features of Pishgu and the improvements achieved over the recent trajectory prediction methods.

1 INTRODUCTION

Current path prediction architectures often lack generality across different domains, making it challenging to develop robust, accurate, and lightweight path prediction models for CPS applications. These models typically focus on a specific context or perspective and fail to evaluate the generality of their solution over different domains and subjects.

Pishgu addresses these challenges by introducing a universal architecture for path prediction based on the graph isomorphism network and attention mechanism. This architecture provides accurate and lightweight path prediction across different domains, allowing for better utilization of edge devices’ limited storage capacity and computational power. Pishgu achieves state-of-the-art accuracy in vehicle bird’s-eye view [4, 7, 11] using NGSIM Dataset [2, 3] and pedestrian high-angle view [6, 8–10] on ActEv/VIRAT [1]. It was also tested on widely used pedestrian path prediction datasets ETH [12] and UCY [5]. Its suitability for real-time CPS applications is demonstrated with low latency across all domains. Path prediction is essential for many CPS computer vision applications, such as pedestrian and transportation safety, intelligent traffic monitoring, and surveillance. Pishgu’s introduction of a single architecture for multiple domains can address these challenges and set a new benchmark for path prediction accuracy in CPS.

In summary, this paper has the following contributions:

• Introducing Pishgu, a universal architecture for path prediction based on graph isomorphism network and attention mechanism.

• Providing performance analysis of Pishgu on major datasets and domains to understand accuracy variations within each domain.

• Demonstrating Pishgu’s state-of-the-art accuracy in two major domains: (1) Pedestrian high-angle view, (2) Vehicle bird’s-eye view.

• Reporting Pishgu’s latency and throughput on NVIDIA Jetson Xavier NX and Jetson Nano, low-power embedded platforms commonly used in real-world edge devices, to show its suitability for real-time CPS applications.

2 PISHGU

Path prediction in different domains inherently depends upon the position, past movements, and end goals of the subjects present in a scene. The end goals and movement patterns vary significantly between different environments (highway, sidewalk, etc.) and subjects (vehicle, pedestrian). However, graph neural networks assist in understanding the varying patterns in the respective domains.
Pishgu uses GIN [13] to grasp the inter-dependencies of all subjects in a scene. Attention-based convolutions are utilized to highlight the important interdependencies and predict the future paths of all the subjects jointly. As we focus on real-time applications of our approach, Pishgu is designed to predict a single path (K = 1) for each subject present in the scene.

3 DEMONSTRATION

In this demonstration, we will showcase the capabilities of Pishgu in predicting trajectories for both pedestrians and vehicles in various real-world scenarios. We will utilize video data from diverse sources, including surveillance cameras and drones, to demonstrate Pishgu’s ability to handle different subjects, perspectives, and scenes. The aim of our demonstration is to highlight the adaptability and robustness of Pishgu in various CPS applications.

To achieve this, we will demonstrate how Pishgu can capture inter-dependencies within the subjects in each frame using GINs and attention mechanisms. We will compare Pishgu with existing solutions on different metrics such as ADE (Average Displacement Error) and FDE (Final Displacement Error) to showcase the effectiveness of our approach. Through our demonstration, we hope to inspire attendees to explore new possibilities for path prediction in CPS applications using Pishgu. Overall, the goal is to provide a comprehensive view of Pishgu’s capabilities and demonstrate its potential for various CPS applications.

Furthermore, in our demonstration, we will use various scenarios that represent different real-world situations, such as crowded areas, and highways, to showcase Pishgu’s versatility in handling diverse scenarios. We will also demonstrate the ability of Pishgu to learn and adapt to new environments by presenting scenarios that were not present in the training dataset. We will showcase the results of our evaluation, where we will compare the performance of Pishgu against state-of-the-art methods on various metrics. We will also highlight the advantages of using Pishgu, such as its ability to predict precise trajectories for each subject in a scene and its robustness in handling complex trajectories.

In addition to the live demonstration, we will also present a poster to provide a visual representation of how Pishgu works and the improvements it has achieved over contemporary trajectory prediction methods. The poster will provide a comprehensive view of the technical aspects of Pishgu and how it can be applied in various CPS applications. It will also highlight the results of our evaluation, showcasing the superior performance of Pishgu over existing methods. The poster will serve as a concise summary of the live demonstration, enabling attendees to gain a better understanding of Pishgu’s capabilities and the advancements it brings to the field of trajectory prediction.

In summary, our demonstration will include the following:

- Utilizing video presentation, showcasing the capabilities of Pishgu within various domains.
- Using a poster to demonstrate technical aspects of Pishgu and highlighting its main features and state-of-the-art results.

We aim to provide attendees with a comprehensive view of Pishgu’s capabilities, inspiring them to explore new possibilities for path prediction using Pishgu.

4 CONCLUSION

Pishgu is a versatile path prediction architecture that utilizes graph isomorphism networks and attention mechanisms for real-time CPS applications. We demonstrate Pishgu’s competency in three domains with extensive analysis of their impact on its performance. The architecture’s ability to adapt to different domains with state-of-the-art accuracy is advantageous for CPS applications. Pishgu is designed for integration into real-world edge-based applications and achieves SoTA performance in the vehicle bird’s-eye and pedestrian high-angle view domains. Further research is needed to improve Pishgu’s accuracy in the vehicle high-angle view domain.

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