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UoT Navigation ChatBot

DSMM - Maple Mapping

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I. Project Overview

This project focuses on the University of Toronto's St. George Campus, spanning 120+ buildings across 53 hectares in downtown Toronto[1]. The objective is to implement an AI-powered chatbot for campus navigation. This tool will assist students, especially newcomers, in navigating the campus and gaining confidence in their surroundings. The Maple Mapping team is tasked with developing a proof-of-concept AI chatbot, showcasing its core functionality—providing accurate responses to campus navigation queries. This serves as a foundation for potential future development and expansion of the solution.

Core Features and Functionalities

- **Efficient Navigation Assistance:** Help students navigate the St. George campus by directing them to specific buildings, amenities, or areas of interest.
- **Informative Responses:** Deliver informative responses through an AI-driven chatbot, allowing students to ask about details regarding building specifications and important information.
- **User-Friendly Interaction:** An interface designed for seamless interactions, ensuring the chatbot appeals to both prospective students and visitors. It aims to deliver an excellent user experience while gathering campus information.

II. Data Collection and Validation

The foundation of AI-powered chatbot for campus navigation at the University of Toronto lies in a meticulously gathered and prepared dataset, serving as the core for generating precise responses to inquiries about campus navigation. It underscores the dedication of the Maple Mapping team to providing a dependable and resilient solution for the University of Toronto community. The data collection process involved extracting essential information from university's map portal, focusing on St. George Campus. Emphasis was placed on the importance of validation to ensure the accuracy and completeness of the collected data.

[1] University of Toronto – St. George Campus map:
https://map.utoronto.ca/?id=1809#!ce/48654?ct/45469,0,48654,48655,48656,48657,48658?s/

Dataset Collection

The team collected data from University of Toronto map portal to create a comprehensive dataset for all building information in St. George Campus as shown in Figure 1. Missing information, such as building descriptions and latitude/longitude, was researched independently to have an enriched dataset.

- **Building Name:** Names of the various buildings within the St. George Campus
- **Address:** Physical addresses of each building for precise location identification
- **Building Number:** Actual assigned building numbers for systematic referencing
- **Description:** Detailed descriptions of each building to enrich the dataset
- **Latitude and Longitude:** Geographical coordinates of each building for accurate mapping

The dataset has been organized in CSV format[2], ensuring ease of storage and later integration into a relational database. This format facilitates seamless handling of the data during the development phase of the St. George Campus chatbot application.

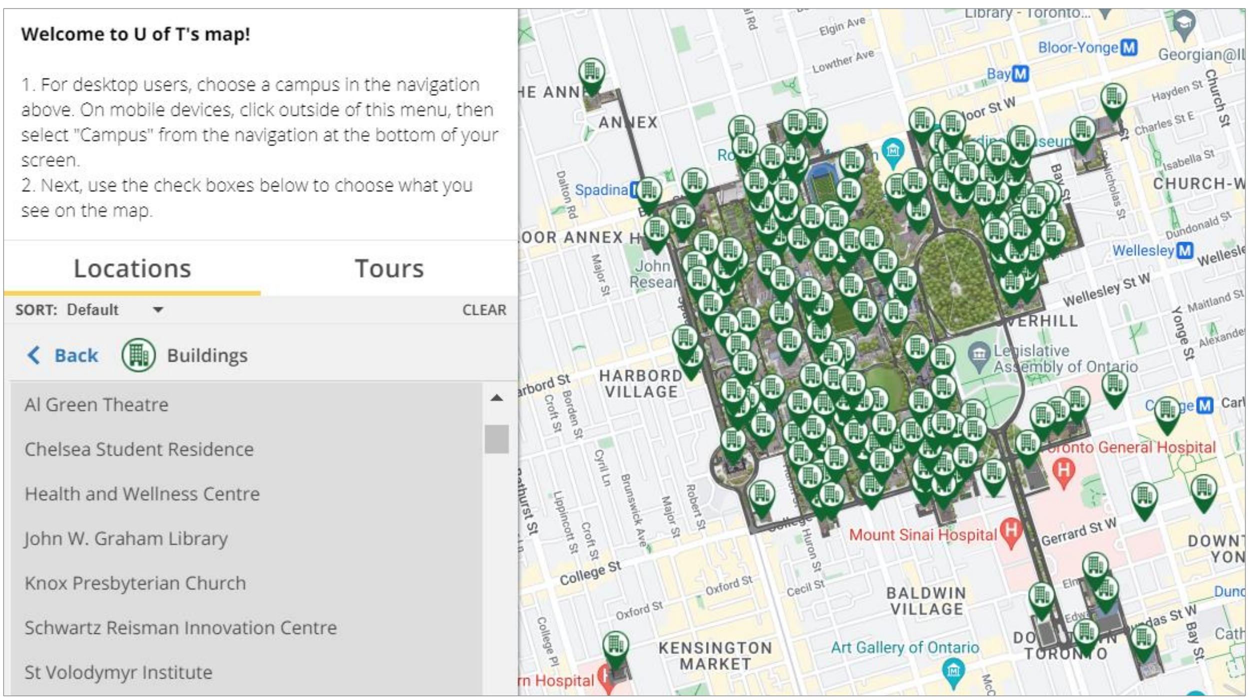

Figure 1 University of Toronto Map for St. George Campus

[2] St. George Campus dataset containing building information: https://www.kaggle.com/datasets/auradee/uot-st-george-campus-building-info/data

Data Cleaning and Validation

The collected data underwent cleaning and validation process. This step was crucial to ensure the completeness and accuracy of the dataset, guaranteeing that it provides informative details about the various buildings within the St. George Campus.

III. ALGORITHM EVALUATION

This section evaluates key AI and machine learning algorithms vital for developing an effective campus navigation chatbot. The analysis considers factors such as intent and named entity recognition, word embeddings effectiveness, machine learning classifier precision, geospatial algorithm reliability, and sequence-to-sequence model coherence. The goal is to ensure these algorithms contribute significantly to the chatbot's accuracy and user-friendly responses for campus navigation queries on the St. George Campus.

Intent Recognition

Intent recognition is the process of understanding the underlying purpose or goal behind a user's input. Natural Language Processing (NLP) based models, such as BERT or GPT, are pre-trained on vast amounts of text data and fine-tuned for specific tasks, making them adept at comprehending the nuanced intent in user queries related to campus navigation.

- **BERT (Bidirectional Encoder Representations from Transformers):** BERT is a pre-trained language model that excels in understanding context and relationships in language. Fine-tuning it with specific campus dataset can help with question understanding and context-aware responses.
- **GPT (Generative Pre-trained Transformer):** GPT models, including GPT-3, can be used for generating human-like responses. These models are initially trained on a diverse set of internet text and can subsequently be fine-tuned for specific tasks, including those related to campus navigation, leveraging relevant datasets.

Named Entity Recognition (NER)

Named Entity Recognition is a component of NLP that focuses on identifying specific entities within a text, such as names, locations, or numerical values. NER algorithms, like those found in Python libraries such as

SpaCy or NLTK, play a crucial role. They extract essential details like building names, addresses, and other key entities from user queries, enhancing the chatbot's ability to provide accurate and relevant responses.

Word Embeddings

Word embeddings, such as Word2Vec and GloVe, can be used to represent words in a continuous vector space. This can help capture semantic relationships between words in the descriptions and improve the model's understanding, thus enhancing the chatbot's ability to comprehend and respond contextually to user queries about campus navigation.

- **Word2Vec:** Word2Vec is a popular word embedding technique that represents words as dense vectors in a continuous vector space. It is trained on large text corpora and captures semantic relationships between words, enabling the model to understand contextual similarities and differences.
- **GloVe (Global Vectors for Word Representation):** GloVe represents words as vectors in a continuous space. It is trained on global statistical information of word co-occurrence and offers a unique perspective by considering both local and global contexts, providing effective embeddings for various NLP tasks.

Machine Learning Classifier

Machine learning classifiers are employed to categorize user queries into different types, such as asking for building names, addresses, or directions. Support Vector Machines (SVM) and Random Forest are commonly used algorithms. These classifiers guide the chatbot to the relevant part of the dataset, ensuring it can extract the right information or generate suitable responses based on the nature of the user's question.

- **Support Vector Machines (SVM):** SVMs can be used for classification tasks, such as intent classification in the chatbot. They work well with high-dimensional data and can be trained on dataset with features like building name, description, etc.
- **Random Forest:** An ensemble learning algorithm that can be used for classification tasks. It's robust and can handle various types of input features, making it suitable for building a Q&A chatbot.

Geospatial Algorithms

Geospatial algorithms are essential for handling location-based queries. This calculates the distance between two points on the Earth's surface using latitude and longitude coordinates, enabling the chatbot to provide accurate information about building locations and offer precise directions within the campus. Geographical Information System (GIS) can be leveraged to calculate distances, find the nearest buildings, and optimize navigation routes.

Sequence-to-Sequence Models

Sequence-to-sequence (Seq2Seq) models, often built with Long Short-Term Memory (LSTM) or Transformer architectures, are designed to understand and generate sequences of data. These models contribute to generating coherent and user-friendly responses. They capture the context of the conversation and produce natural-sounding replies, enhancing the overall conversational experience for users.

IV. CHATBOT PROTOTYPE

This section charts a streamlined approach for building a functional chatbot prototype, showcasing the potential of AI-powered navigation. The team meticulously selected efficient and effective machine learning algorithms, prioritizing lightweight computing. Figure 2 illustrates the diagram of chatbot’s functional prototype designed for the St. George Campus Navigation system. The following provides an explanation for each step outlined in the diagram.

1. **User Input:** Users engage with the chatbot by providing input through text or voice commands, seeking assistance for various queries related to navigating the St. George Campus.
2. **Intent Recognition:** The GPT intent recognition module identifies the user's goal, such as locating a building by its name or number and obtaining directions. GPT model is fine-tuned using the dataset of labeled intents specific to St. George campus needs.
3. **Entity Recognition (Optional):** Depending on the intent, specific building names, addresses, or Point of Interest (POI)s are extracted from the user input using the NER model trained specifically using St. George campus entities.
4. **Knowledge Base Lookup:** The chatbot's knowledge base, containing building details, POIs, and campus map data, uses Word2Vec word embedding for semantic search, enabling it to understand the user’s intent and provide relevant information efficiently.
5. **Geospatial Processing (Optional):** The geospatial module calculates optimal paths using a GIS library or campus map API for turn-by-turn directions.

6. **Response Generation:** The response generation module, informed by the knowledge base and geospatial data, formulates a natural language response. Pre-designed templates are available for common responses based on identified intent and entities, and fine tune a GPT model on campus-specific data to personalize responses and handle variations.
7. **ChatBot Response:** The chatbot delivers the response to the user through text or voice, contributing to a comprehensive and user-centric St. George Campus navigation experience.

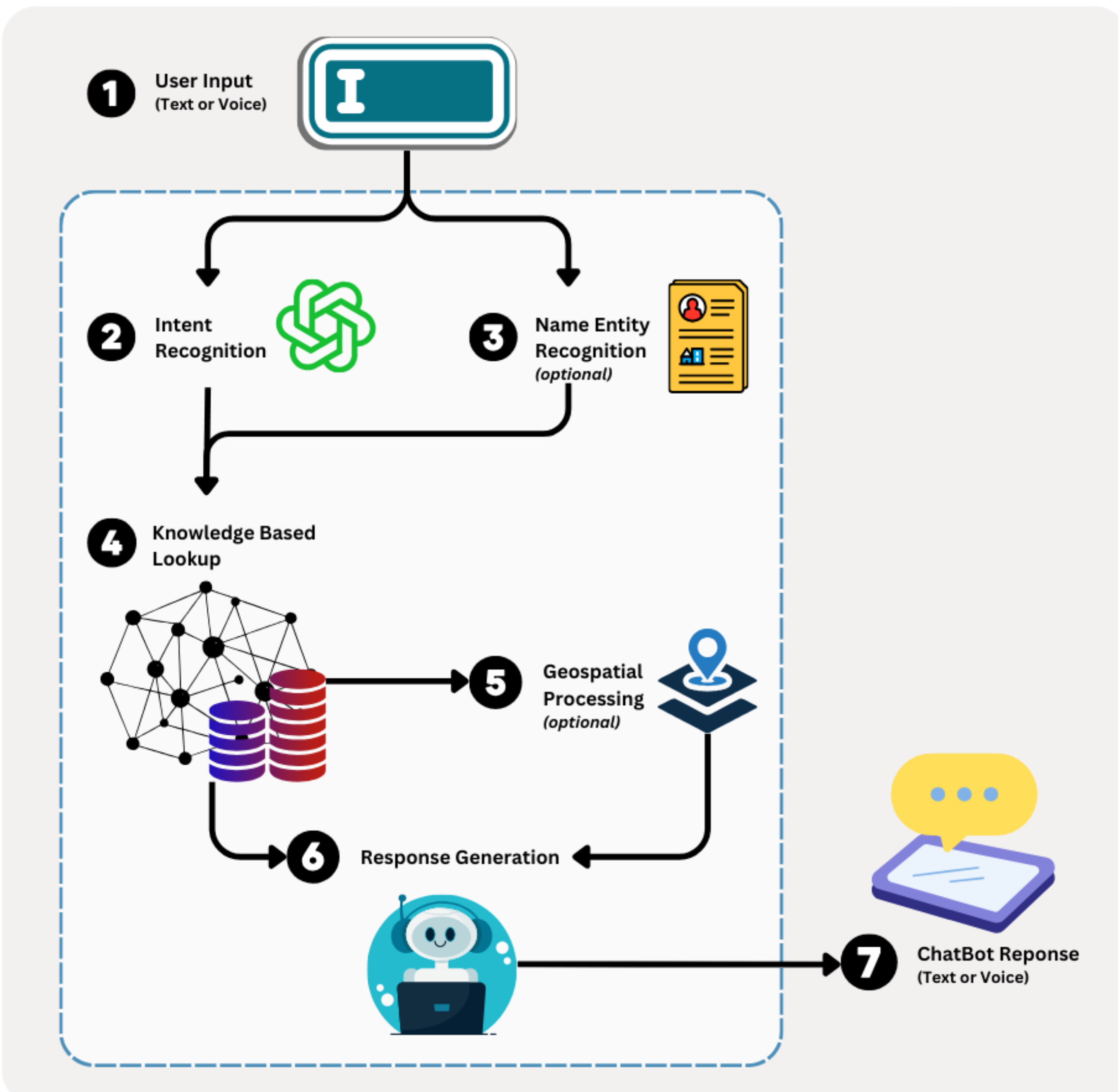

Figure 2 Prototype of Machine Learning-Enhanced Campus Navigation ChatBot

V. RECOMMENDATIONS

The following recommendations aim to enhance the chatbot app's functionality, extending beyond basic campus building navigation. By incorporating features such as expanded navigation options, event notifications, integration with campus services and a feedback mechanism, the app can provide a more comprehensive and user-friendly experience for students, faculty, and staff.

- **Expanded Navigation Features:** Extend the chatbot's capabilities to include navigation and information on key campus areas such as the library, parking facilities, transportation options, and food areas. This ensures users can easily find and navigate to various essential locations on the campus.
- **Event Notifications and Student Programs:** Integrate real-time event notifications, keeping users informed about school events, student programs, and services, including date reminders, program invitations, and updates on campus activities.
- **Integration with Campus Services:** Incorporate campus services for streamlined user access. Users can inquire, schedule appointments, and receive guidance on academic support, counseling, and other student services directly through the chatbot.
- **Feedback Mechanism:** Integrate a feedback loop into the app to capture user opinions and suggestions. Analyze this feedback regularly to continuously improve and adapt to the evolving needs of the campus community, ensuring a user-centric experience.