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A SEMANTIC WEB APPROACH: CREATING A TOURISM ONTOLOGY FOR CHITTAGONG DISTRICT

This Dissertation is Submitted in Fulfillment
of the Requirements for the Degree of

Bachelor of Science (B.Sc.)

in

Computer Science and Engineering (CSE)

by

MD. Rohmat Ulla (C191033)
Suliman Hossain Riyad (C191025)
Rakib Hasan Rahat (C191016)

TO
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG
Spring 23

DECLARATION

We hereby affirm the following statements regarding our thesis:

1. The thesis has been successfully completed as part of our undergraduate degree program at International Islamic University Chittagong.
2. The thesis work does not contain any previously published or third-party content without proper citation.
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SUPERVISOR'S DECLARATION

I formally state that I have examined this thesis and claim it to be of sufficient quality and scope to be granted for the undergraduate degree of Bachelor of Science in Computer Science and Engineering.

Dr. Engr. Mohammad Aman Ullah
Associate Professor
Chairman (in-charge)
Department of Computer Science and Engineering
International Islamic University Chittagong

DEDICATION

This thesis report is dedicated to us, our supervisor and our family. The team work was satisfactory and the family's support was incredibly Amazing. Our dedicated and most hard working Supervisor who has been a constant support throughout these months. In this document, the contributions are acknowledged too.

ACKNOWLEDGMENT

To start with, All the praises to the Almighty Allah, for his mercy because of which we were able to finish our thesis despite having so many obstacles. Secondly, we would like to extend our gratitude to our supervisor, Dr. Engr. Mohammad Aman Ullah for his continuous effort and guidelines from the very beginning of our research.

ETHICAL STATEMENT

Hereby we state that, None of the unethical practices were used in the completion of our thesis work. The data we used for the research purpose are original. We carefully checked every citations we used here. The two writers of the work accept all the liabilities for any kind of violation of the thesis rule.

ABSTRACT

The purpose of this thesis is to utilize the Semantic Web, a web of interconnected meaning, to develop a comprehensive tourism ontology for Chittagong district. This paper implemented ontology on tourism domain, proposed a general framework for tourism ontology and explained searching mechanism through Chittagong district tourism. Also, it presents different ways of reasoning the ontology. In general, ontology classifies the variables in need for some computations and creates interrelationships between them. The introduction of semantic web poses the demands for creating ontology in many domains. We have found that the utilization of ontologies within the tourism domain remains relatively limited. Notably, research into ontologies specifically focused on Chittagong tourism is entirely absent. To address this gap, this study proposed the development of a dedicated Chittagong tourism ontology. In the digital age, tourism thrives on readily available information and efficient organization. This thesis delves into the creation of a robust tourism ontology for Chittagong district, Bangladesh. By formalizing knowledge about tourism resources, attractions, and experiences, we aim to enhance information retrieval, facilitate data integration within the tourism sector. This ontology leverages the expressiveness of Web Ontology Language (OWL) to model the intricate relationships between various tourism entities. We capture details about historical sites, cultural attractions, natural wonders, transportation networks, foods and accommodation options. The ontology also incorporates relevant concepts like accessibility, sustainability, and cultural sensitivity.

Keywords: Semantic Web, Ontology, Tourism, Chittagong district, Bangladesh, OWL, Information Retrieval, Data Integration.

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Chapter 1

Introduction

1.1 RESEARCH BACKGROUND

The Semantic Web aims to enhance the meaning of information by enabling data to be not only machine-readable but also interpretable by computers. According to Berners-Lee , semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation. Authors in paper [1] endeavors to apply Semantic Web technologies, encompassing ontologies, semantic content annotation, and semantic search, within the tourism sector.

Ontology, within the context of the Semantic Web, plays a crucial role as a formalized framework for knowledge representation. In paper [2], the study describes ontology as a systematic framework for representing knowledge and conducting conceptual analysis. The significance of ontologies stems from their ability to facilitate the generation, aggregation, and application of semantic knowledge based on robust and meticulously built ontological frameworks. [3]

A special type of ontology called Touringology, an ontology aimed at improving tourism planning by providing detailed information about accommodations, food, transportation, and attractions in tourist areas, was proposed in paper [4]. The emphasis lies on explicitly defining conceptualizations within the domain to improve knowledge management and information retrieval.

The tourism industry is an essential driver of economic growth, and it is imperative to investigate novel strategies for improving visitor experiences and information availability.

In paper [5], tourism is described as an intricate structure involving many participants and interactions that influence economies, communities, and landscapes. This complication emphasizes the significance of meticulous planning and policy administration.

KNOEMA, a New York-based data technology company, reveals that the travel and tourism sector contributed 4.4positive trajectory, pales in comparison to other South Asian nations. For example, in 2019, tourism contributed 10.9potential for Bangladesh to bridge the gap. Furthermore, the World Economic Forum's 2021 Travel and Tourism Competitiveness Index paints a similar picture. Bangladesh's ranking of 117th out of 140 countries, despite its diverse natural beauty and rich cultural heritage, suggests room for considerable improvement in attracting and catering to tourists.

According to Wikipedia, Bangladesh welcomed only 323,000 tourists in 2019, highlighting a significantly low figure in relation to its total population, offering insights into the country's tourism landscape.

Examining a wide array of publicly accessible tourism ontologies and their applications across diverse research projects, this paper [6] presents a thorough survey. The results underscore Protege's prominence as a key tool for ontology development, with SPARQL identified as the primary query language.

According to the authors of the paper [7], Chittagong City has transformed from a modest port into the primary catalyst for economic advancement in the region. Nevertheless, it confronts obstacles arising from rapid population expansion, dispersed industrial sites, and inadequate infrastructure. Despite these challenges, the city holds significant historical, socio-economic, and cultural influence on Bangladesh's economy.

Even though Chittagong District offers a wide variety of attractions, such as historical sites, natural wonders, and cultural landmarks, the exploration and application of ontological frameworks in the context of Chittagong tourism have remained notably underexplored. Therefore, there is a lack of comprehensive, user-friendly, and interactive information for potential tourists. Websites, posters, flyers, and seminars are just a few of the current information-dissemination methods that are intrinsically unable to address the unique requirements and inquiries of prospective visitors.

1.2 PROBLEM STATEMENT

Based on the insights from the background of the study and related works section, it is evident that the use of ontological frameworks in tourism, notably in Chittagong, Bangladesh, has been understudied and unexplored This gap is noticeable due to the lack of dedicated tourism ontologies such as Touringology, which has an impact on decision-making and tourist planning. Despite the recorded development in tourism earnings in Bangladesh, its relatively lesser contribution to national GDP in comparison to other South Asian countries shows unfulfilled potential. In the context of Chittagong, a significant economic hub confronting urbanization issues, the city's potential to cater to a bigger tourist base is further hampered by a lack of personalized concepts and complete information tools for tourists.

1.3 MOTIVATION

This thesis is motivated by the need to bridge significant information gaps in Chittagong District. Visitors are currently having difficulty gaining a comprehensive understanding of the available attractions, cultural events, and historical sites. Tourists' ability to make well-informed decisions is hampered by the fragmented nature of information dissemination, limiting their exploration potential.

Another source of motivation is the goal of facilitating personalized exploration. Visitors struggle to tailor their experiences in the absence of a structured framework for information distribution, resulting in missed opportunities to discover destinations aligned with their specific interests.

Inefficiencies in information retrieval methods highlight the need for improvement even more. Current methods, such as websites and search engines, frequently fail to filter and present relevant data to tourists. This inefficiency frustrates visitors and limits their ability to fully engage with Chittagong District's diverse offerings.

Furthermore, the study is motivated by a lack of interactive visitor guidance. Travel planning is complicated by the lack of tailored information on optimal routes, transportation options, and accommodations. This flaw in a user-centric approach jeopardizes convenience and may influence suboptimal choices during visitors' stays.

Finally, the motivation for this research stems from a desire to contribute to the long-term growth of the tourism industry in Chittagong District.

1.4 OBJECTIVE OF RESEARCH

The Objective of this research is to create a comprehensive and user-centric tourism-specific ontology for the Chittagong District that improves the availability, accessibility, and customization of information for tourists. Focused on addressing the current lack of dedicated tourism knowledge representation, the research will systematically develop the ontology, covering key aspects such as accommodations, food, transportation, and attractions.

1.5 ORGANIZATION OF THE THESIS

The thesis comprises of five chapters.

Chapter 1 serves as a solid cornerstone by offering a complete review of the entire argument, This introductory chapter captures the essence of the study, elucidating the context through an exploration of the research background, a clear delineation of the problem statement, a deep dive into the motivating factors driving this study, a delineation of the meticulously defined research objectives, and finally, an elucidation of the overarching organizational structure used throughout this academic endeavor.

The second chapter critically explores the current literature on the tourism business in Chittagong District. It includes an examination of existing information transmission methods, the significance of the Semantic Web and ontology, tourist issues, and a review of recent research in tourism ontology creation.

The research methodology and approach used in this study are described in depth in Chapter 3. It outlines the data gathering and analysis technique, the design and development process of the tourism-specific ontology, implementation tactics, and the evaluation and testing criteria.

The research findings are presented in Chapter 4. It includes data compilation, ontology development outcomes, implementation and testing findings, assessment metrics, and a full discussion examining the effectiveness, usability, and comparison with existing methodologies.

Chapter 5 summarizes the study's important findings, stressing the accomplishments and contributions achieved through the establishment of the Chittagong District tourism-specific ontology. It examines constraints, makes recommendations for further research, and finishes the thesis by underlining the importance of the suggested solution for the tourism business in the region.

Chapter 2

Literature Review

2.1 INTRODUCTION

2.1.1 SEMANTIC WEB

Sir Tim Berners-Lee, the progenitor of the World Wide Web, describes the Semantic Web as "a web of data that can be processed directly and indirectly by machines." In his exposition in Scientific American in 2001, he elaborates on "The Semantic Web" as a nascent form of web content that is significant for computational entities.It aims to make information on the web more easily processed and understood by machines, enhancing efficiency and efficacy in communication and collaboration between human entities and computational systems. [8],[9]

The Semantic Web aims to surpass the limitations of the World Wide Web, transitioning from a mere repository of unstructured documents to a dynamic web of interconnected data. This data, imbued with both human and machine-comprehensible meaning, effectively transforms information into knowledge. For this ambitious vision to materialize, computers require access to two crucial elements: structured information and automated reasoning capabilities, or sets of inferential rules. Fortunately, two foundational technologies pave the way for the Semantic Web:Extensible Markup Language (XML) and the Resource Description Framework (RDF). XML provides a standardized structure for web documents, while RDF offers a language for expressing relationships between resources in a machine-readable format. RDF facilitates automated reasoning, empowering machines to analyze data, draw inferences, and even generate new knowledge. [9], [10]

However, a crucial distinction must be drawn: the Semantic Web focuses on machine-understandable semantic documents and data, not the intricacies of human language. Ambiguity inherent in human language can disrupt automated reasoning, and therefore, the Semantic Web relies on unique URIs assigned to specific concepts,ensuring consistent and unambiguous identification across the web.Unlike words in a document, URIs serve as unique and globally accessible identifiers, ensuring that each concept corresponds to a single, well-defined entity. This removes the ambiguity inherent in human language and allows machines to reason accurately by referring to clearly defined concepts. [10]

In the context of the Semantic Web, an ontology serves as a formalized conceptualization of knowledge within a domain. It defines the key concepts and relationships within that domain, establishing a common semantics,facilitating the structured and meaningful interpretation of data by both humans and machines. This crucial role makes ontologies fundamental to achieving the vision of a more intelligent and machine-understandable web.The significance of ontologies lies in their ability to facilitate the creation, integration, and utilization of semantic data, which is contingent upon robust and well-developed ontologies.[3]

The RDF model utilizes a vocabulary defined by the terms of the ontology, while the associated XML schema provides the structural framework for representing the data. This combination gives computers sufficient information to extract and interpret the semantic content of data, paving the way for a more intelligent and interconnected web.[3]

In conclusion, ontologies are more than mere building blocks; they are the lifeblood of the Semantic Web. Their ability to formalize knowledge and relationships paves the way for a future in which machines can process information, but also understand and reason with it. Continued research in ontology development, integration, and reasoning techniques remains crucial to fully realize this transformative vision.

2.1.2 ONTOLOGY

Ontology is the philosophical study of the nature of being, existence, or reality. In computer science, ontology refers to the formal representation of knowledge within a domain, including the entities, relationships, and properties that exist within that domain. It provides a structured framework for organizing information and knowledge, allowing for more effective knowledge management, information retrieval, and reasoning. It helps organize and structure information in a way that can be understood by both humans

and computers.

In [2], the paper proposes the use of formal ontology as a structured framework for knowledge representation and conceptual analysis, emphasizing the explicit specification of conceptualizations within a domain to enhance knowledge management and information retrieval. It also highlights the importance of ontological analysis in addressing the challenges of knowledge representation and conceptual clarity.In [11], the paper discusses the various interpretations and uses of ontologies in different communities, emphasizing the significance of shared explicit specifications, and addressing the challenges related to conceptualization and interpretation in ontological modeling.The paper suggests that an ontology is a formal, explicit specification of a shared conceptualization, which requires minimal shared ontological commitment and well-founded basic primitives to facilitate communication and support large-scale interoperability.In the philosophical sense, it has a well-established tradition, while in the computational sense, it emerged in the knowledge engineering community as "explicit specifications of conceptualizations".In [12], the paper suggests that information ontologists may have pragmatic reasons to take the philosopher ontologist's traditional concern for truth more seriously. It also discusses the importance of conceptualizations in various settings and the role of ontology in reducing inconsistency and systematic errors in theories. Additionally, it highlights the challenges and potential rewards of a real-world directed ontology.

These three highly cited papers offer valuable insights into the multifaceted nature of ontology. Understanding their diverse perspectives and points of comparison is crucial for navigating the rich theoretical landscape of this domain.Overall, all three papers contribute significantly to the understanding of ontologies, but with different emphases. Papers [2] and [11] focus on the practical applications and challenges of ontologies in knowledge management and communication, while paper [12] bridges the philosophical and computational perspectives, highlighting the importance of truth and conceptual clarity.

2.1.3 BANGLADESH TOURISM

Tourism, in academic terms, encompasses the multifaceted phenomenon involving the movement of individuals or groups to destinations beyond their habitual environment for recreational, cultural, or business purposes. This often involves activities, experiences,

and interactions within the visited location.In [5], tourism is a complex system involving diverse actors and interactions, impacting economies, societies, and landscapes, and necessitating careful planning and policy management.

The tourism industry's contribution to economic growth is well-established, demonstrably impacting both developed and developing nations. While Bangladesh has witnessed a burgeoning tourism sector, claiming that it is one of the "most profitable" requires further scrutiny.According to Choice for Economic and Investment Research (CEIC) data (2021), Bangladesh witnessed a remarkable 478% increase in tourism revenue between 2005 and 2019. This translates to a jump from a mere USD 82 million in 2005 to a substantial USD 392 million in 2019, highlighting the sector's rapid growth trajectory and its burgeoning contribution to the national economy.Compelling evidence of this pre-pandemic upsurge is provided by the Bangladesh Bureau of Statistics (BBS) in its Statistical Yearbook Bangladesh 2022. The report reveals that in 2019, Bangladesh welcomed a total of 621,131 tourists, a noteworthy figure that highlights the sector's potential.Further substantiating this upward trend is data from the World Bank (2021). It indicates that between 2000 and 2019, the number of international tourist arrivals in Bangladesh witnessed a 62.31% increase, rising from 199,000 in 2000 to 323,000 in 2019. This sustained growth underscores the increasing appeal of Bangladesh as a tourist destination.

2.1.4 CHITTAGONG TOURISM

Chittagong, a coastal city in southeastern Bangladesh, holds profound significance in the realm of tourism. Renowned for its picturesque landscapes, historical landmarks, and vibrant cultural tapestry, Chittagong attracts a diverse array of visitors. Geographically, Chittagong offers a breathtaking landscape that includes the scenic Hill Tracts, pristine beaches such as Patenga, and the evergreen forests of Sitakunda. Venture to Cox's Bazar, where golden sands stretch endlessly along the Bay of Bengal, inviting sunbathers and surfers alike.

But Chittagong's charm lies not just in its landscapes, but also in its diverse cultural tapestry. Throngs of devotees gather at the centuries-old Shrine of Bayazid Bostami, while Buddhist pagodas whisper stories of ancient wisdom. Experience the pulsating rhythm of tribal dances at the Rangamati Cultural Center, or savor the delicate flavors of Bengali cuisine, a symphony of spices and aromas. This diversity ensures that Chittagong caters to a wide spectrum of tourists, from history enthusiasts

and cultural aficionados to nature lovers seeking a rich and immersive experience in Bangladesh.Chittagong's multifaceted allure makes it a pivotal hub within Bangladesh's tourism landscape.

Nestled in the heart of Bangladesh, Chittagong's tourism weaves a tapestry of economic benefits. Travelers flock to its sun-kissed beaches and verdant hills, injecting foreign exchange into local businesses. This influx fuels job creation in hotels, restaurants, and transportation, boosting livelihoods and alleviating poverty. As the infrastructure expands to accommodate visitors, it spills over, enhancing connectivity and benefiting the entire region. Chittagong's tourism, in essence, paints a vibrant picture of economic growth, brushstroke by tourist, that enriches the city and beyond.

2.2 RELATED WORK

This section reviews various papers related to tourism ontologies.

In [13], the paper proposes an Ontological Recommendation Multi-Agent System (ORMAS) that utilizes various technologies, such as ant colony optimization, context reasoning, and the Google Maps API, to provide a personalized travel recommendation system. This can help tourists find information that is relevant to their interests and preferences, providing a better travel experience. The domain ontology for Tainan City travel can be applied to other cities or fields.

In [14], the paper proposes the integration of heterogeneous information for online tour planning using ontologies and formal concept analysis (FCA). Specifically, the authors develop an ontology for tourists and an integrated ontology for tourism information providers. These ontologies are then mapped to match the perspectives between tourism service users and providers. The authors also discuss the potential of using these ontologies to develop semantic web-based tourism information systems.

In [15], the paper proposes the construction of a tourism-type ontology framework based on the analysis of naming elements and connotations extracted from existing tourism literature, providing a comprehensive classification system for various tourism types. Additionally, the framework serves as a foundation for organizing overall tourism knowledge and constructing a unified naming rule for tourism types.However, the study does not

provide a detailed methodology for constructing the ontology.

In [16], the paper proposes a general framework for ontology development and demonstrates its application in developing an ontology for a university domain using Protégé 4.3.1. The paper also proposes the use of reasoning tools to check the reliability and consistency of the ontology. The paper does not cover all the concepts and related restrictions of the university.

While the authors [17] proposed a promising university ontology for the semantic web using Protégé OWL, their work suffers from a limited explanation of the development process and lacks a comprehensive evaluation of its effectiveness, hindering its broader impact.

This paper [6] conducts a comprehensive survey of publicly available tourism ontologies and their applications in various research projects. Among the surveyed ontologies, Harmonise focuses on accommodation, attractions, and food facilities, while Qall-Me encompasses accommodation, sites, events, and transportation, even mapping to external ontologies like WordNet and SUMO. OnTour and Hi-Touch offer additional functionalities like activity representation and rapid query response times. Notably, the survey reveals Protégé as a prominent tool for ontology development, with SPARQL serving as the primary query language. These findings highlight the diverse landscape of tourism ontologies and their potential to enhance information retrieval and analysis in the field.

This paper [1] aims to utilize Semantic Web technologies, including ontologies, semantic content annotation, and semantic search, in the tourism industry. It conducts a state-of-the-art analysis, identifying and evaluating existing tourism ontologies and management tools, and seeks to optimize search by integrating formal and social semantics with traditional keyword methods.

The paper [18] advocates for the development of CURIOCITY, an ontology designed to model cultural heritage knowledge in urban tourism, aiming to provide a standardized and structured representation of cultural heritage information in the context of urban tourism. A more holistic evaluation encompassing user engagement, application performance, and measurable effects on tourism sustainability would strengthen the argument for CURIOCITY's effectiveness and future adoption.

The paper [19] introduces a cultural tourism ontology for Lower Northern Thailand, evaluated for data retrieval efficacy and correctness using conventional methods such as precision and recall. Designed to facilitate semantic search, the ontology addresses the unique characteristics of tourism assets, emphasizing its potential integration with e-tourism platforms, websites, and mobile applications for enhanced accessibility and user relevance. However, the paper would benefit from a more detailed discussion of the specific metrics used in ontology evaluation and their limitations to bolster the study's methodological robustness.

Aiming to enhance information retrieval and personalization in Malaysian tourism, this paper [20] proposes the "Malaysian Tourism Ontology," a structured knowledge framework that organizes and links relevant concepts. This machine-readable ontology facilitates information reuse and program development, ultimately fostering efficient and accessible tourism information structures for users.

The authors [21] introduce a user-centric recommender system architecture for e-tourism that combines PULL and PUSH approaches, ontology-based context modeling, and an aging-like algorithm to enrich serendipity in recommendations.By considering user profiles, preferences, and contextual parameters, the proposed system aims to deliver personalized and surprising recommendations for tourism activities, considering both user preferences and context.

This paper [22] addresses the challenge of ineffective tourist information retrieval in African tourism by presenting a seven-step manual process for constructing a domain ontology. Emphasizing ontology reasoning and consistency checking, this paper highlights the potential benefits of using the African tourism domain ontology for users seeking comprehensive information.

Aiming to streamline tourist planning, this paper [4] proposes Touringology, an ontology that offers detailed information on accommodations, food, transportation, and attractions in tourist areas. While the paper lacks explicit mention of the specific axioms employed, its focus on enriching information access for tourists holds significant potential for enhancing travel planning experiences.

The authors in paper [23] advocate for the application of Ontology methods in constructing a comprehensive travel ontology, utilizing OWL DL to define categories, attributes,

relationships, axioms, and instances. While it demonstrates consistency checking and implicit knowledge access, it lacks empirical evaluation of the ontology and its reasoning mechanism.

This paper proposes an OWL ontology for the e-tourism domain of Chittagong, aiming to address limitations in automated processing, interoperability, and integration. It expands upon existing ontologies that focus on "what" and "where" to visit by also modeling "what to do" activities, enriching information retrieval for e-tourism applications through Chittagong-specific context.The proposed ontology defines super classes such as 'chittagong,' 'Tourism_Attraction,' 'transport_system,' 'accommodation,' 'tourism_type,' and 'Place_info,' offering a comprehensive framework for enhancing e-tourism information management.[24]

2.3 SUMMARY

The growing landscape of online tourism information presents undeniable challenges, particularly for cities like Chittagong, which boasts a rich tapestry of historical, cultural, and geographical offerings. The summaries of individual papers, such as [22], [4], [20], and [21], provide insights into specific ontologies and recommender systems.Papers [2], [11], and [12] explore the practical applications and challenges of ontologies, bridging philosophical and computational perspectives. While existing research provides valuable insights into developing ontologies for city-based tourism, a dedicated framework for Chittagong remains conspicuously absent.Several academic efforts demonstrate the potential of ontologies in the domain of tourism. "CURIOCITY", "Malaysian Tourism Ontology","Tainan City Travel Ontology" are some examples of city-based tourism ontologies.Despite these notable contributions, it is pertinent to highlight the absence of a tourism-based ontology specifically tailored for Chittagong City in extant literature. This thesis explores the potential of adapting and extending existing research to address this gap, ultimately enhancing the tourism experience for both visitors and residents.This paper contributes to the e-tourism domain by proposing a novel ontology for Chittagong.

Chapter 3

Methodology: Unveiling The Blueprint

3.1 OVERVIEW OF THIS CHAPTER

Chittagong's rich history,unique location, cultural tapestry, stunning natural beauty, and vibrant experiences make it a thriving tourist destination. To map its diverse offerings, this study employs a multi-pronged approach. First, relevant thanas and upazilas are identified based on established attractions. Then, specific destinations within those areas are pinpointed using official government websites and Wikipedia. Finally, detailed attributes such as local cuisine, leisure facilities, and natural beauty are investigated through direct observation, interviews, online sources, and official websites. This comprehensive data collection fuels the development of a user-centric tourism ontology for Chittagong, facilitating efficient exploration of its rich tapestry.

This methodology chapter outlines a rigorous nine-step approach for constructing a comprehensive tourism ontology for Chittagong District. The initial stages, encompassing steps 1-4, focus on defining the ontology's domain and scope, and laying the groundwork by examining existing ontologies for potential reuse, enumerating relevant terms, and defining the core classes and their hierarchical relationships. Subsequently, steps 5-6 delve into defining object and data properties specific to the Chittagong tourism domain. Subsequent steps (7) involve populating the ontology with instances and relationships, enriching its knowledge base. Finally, steps 8 and 9 employ reasoning techniques and query-based evaluation to assess the ontology's efficacy and ensure its successful application in tourism-related knowledge retrieval and analysis.This meticulous workflow ensures the ontology's robustness and effectiveness in serving the needs of both researchers

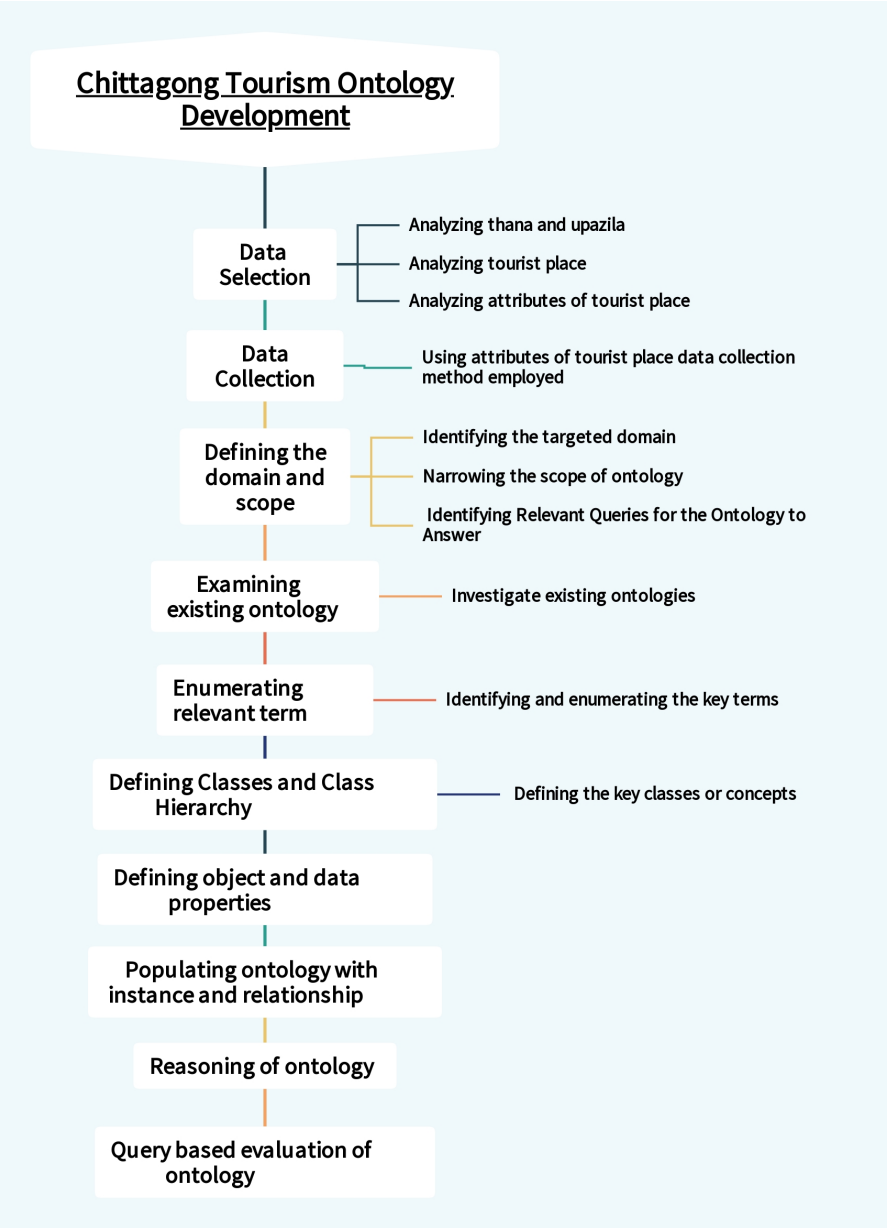

Fig. 3.1. Methodology for Chittagong Tourism Ontology Development

and tourists in the Chittagong District.

This thesis embarks on a journey to chart a course for a more informed and enriching tourist experience in Chittagong, with a robust framework for knowledge representation, retrieval, and reasoning. Our methodological approach prioritizes user-centricity, ensuring that the ontology caters to the specific needs and information gaps faced by diverse tourist groups.

3.2 DATA SELLECTION

The city of Chittagong boasts a rich history centered around its ancient seaport, established in the 4th century BCE. This strategic location, coupled with a naturally formed harbor, has cemented Chittagong's position as the oldest and largest natural seaport in the Bay of Bengal. Situated on the banks of the Karnaphuli River, nestled between the Chittagong Hill Tracts and the Bay of Bengal, Chittagong offers a unique blend of natural beauty and urban vibrancy.

This study focuses on the tourism landscape within Chittagong city.Data acquisition for these destinations was conducted through a multi-pronged approach:

3.2.1 THANA AND UPAZILA SELECTION

Given its administrative structure, the city is divided into sixteen metropolitan "thanas" (police stations) and fifteen non-metropolitan "upazilas" (sub-districts). Recognizing that not all administrative units hold equal significance for tourism, the initial data preprocessing step involved identifying relevant areas based on the presence of established tourist destinations. This identification process involved applying a simple rule: any "thana" or "upazila" containing at least one recognized tourist attraction was deemed relevant for the study.

Employing this rule, the research narrowed its focus to seven "thanas" and eight "upazilas" within the Chittagong district, encompassing a total of fifteen key tourist destinations area.

3.2.2 TOURIST DESTINATION IDENTIFICATION

Following the selection of pertinent thanas and upazilas, the next step involved identifying specific tourist destinations within these areas.Information regarding these destinations was acquired from two primary sources:

Official government websites: The People's Republic of Bangladesh government website (https://www.chittagong.gov.bd/en) served as a primary source of verified information on administrative boundaries, tourist attractions, and official descriptions of

each destination.

Wikipedia: As a widely recognized online encyclopedia, Wikipedia provided supplementary information on the historical significance, cultural aspects, and specific features of each tourist destination.

3.2.3 TOURIST DESTINATION ATTRIBUTES IDENTIFICATION

To enrich the data further, we delved into the specific attributes that attract tourists to these locations. This involved investigating factors such as:

Local and international culinary offerings: Do specific cuisines or dishes draw visitors? What is the availability and variety of food options?

Leisure and entertainment facilities: What recreational activities or amenities are available (e.g., rides, water sports)?

Infrastructure and connectivity: How accessible is the destination? What is the quality of mobile network coverage?

Natural environment and aesthetics: Does the location offer scenic beauty, unique landscapes, or other natural attractions?

3.3 DATA COLLECTION

Once the target tourist destination and attributes were identified, a multifaceted data collection methodology was employed. This approach combined various avenues to ensure inclusivity and accuracy:

3.3.1 DIRECT OBSERVATION AT TOURIST PLACES

Recognizing the value of firsthand experience and local insights, the research incorporated visits to accessible tourist destinations within the narrowed scope. And gather firsthand data on various attributes, including local and international cuisine options, available amenities, entertainment options, mobile network connectivity, and overall ambiance.

3.3.2 LOCAL KNOWLEDGE AND EXPERT INTERVIEWS ABOUT TOURIST PLACES

Interviews were conducted with residents of relevant areas familiar with the local tourism landscape, as well as individuals possessing expert knowledge of specific tourist destinations in Chittagong.

3.3.3 ONLINE SOURCES OF TOURIST PLACES

When direct access or interviews proved infeasible, the research utilized various online resources, including Google searches and YouTube videos, to gather additional data on specific tourist places.

3.3.4 OFFICIAL WEBSITES OF TOURIST PLACES

Where available, dedicated websites for individual tourist destinations provided valuable insights into their unique offerings, amenities, and target audience.

After collecting data on tourist destination attributes, we use it to populate the ontology with concrete instances or individuals, thereby enhancing the semantic representation of this domain.

The processed and verified data served as the foundation for building our comprehensive and user-centric tourism ontology for the Chittagong District. This ontology, the subject of the following sections, aims to organize and interlink information about tourist destinations in a structured and accessible manner, empowering users to explore Chittagong's diverse offerings with ease.

3.4 METHODOLOGY

This undertaking involved a systematic exploration, guided by the following key steps:

Step 1: Determining the Domain and Scope of the Ontology

1.1 Domain Selection

The initial step in constructing our ontology involved identifying the targeted domain. We began by brainstorming a series of questions, the first of which aimed to define the domain the ontology would encompass. Through this process, we concluded that the tourism domain would be the most relevant and impactful area to focus on. Notably, the designated reference location or area for this study is the Chittagong District.

This decision was motivated by the city's rich cultural heritage, diverse attractions, and potential for tourism development, including the abundance of information available on tourism, the potential for practical applications, and our personal interest in the field.

1.2 Defining the Scope

Further narrowing the scope, we determined that our ontology would primarily target three user groups:

Tourists: Individuals visiting Chittagong with limited knowledge of the city's attractions and activities.

Residents: People residing in Chittagong who may not be fully aware of the city's diverse tourist offerings.

New Residents: Individuals recently relocated to Chittagong who are seeking information about local attractions and experiences.

1.3 Identifying Relevant Queries for the Ontology to Answer

After establishing the domain and scope of our tourism ontology for Chittagong, we focused on defining the types of questions it should be capable of answering. This step involves analyzing the needs and potential queries of our target audience. We envisioned the ontology serving as a knowledge base for users seeking information on diverse aspects of Chittagong's tourism landscape.

To gain a deeper understanding of users' information needs, we developed a set of sample questions that would serve as benchmarks for evaluating the coverage of our ontology.These questions encompass various aspects of tourism, including:

Places of Interest:

"What are the best places for children in Chittagong?"
"What are some historical landmarks in Chittagong?"
"Are there any natural parks or gardens in Chittagong?"

Activities:

"What kind of activities can be done at the beach in Chittagong
"Where can I go hiking or biking in Chittagong?"
"Are there any water sports available in Chittagong?"

Museums and Exhibits:

"What museums are there in Chittagong?"
"What kind of exhibits can be seen at the Chittagong Museum?"
"Are there any art galleries or cultural centers in Chittagong?"

Accessibility:

"Which tourist attractions are wheelchair-accessible?"
"Are there any child-friendly restaurants near tourist attractions?"
"What is the public transportation like in Chittagong?"
"Are there any sea beaches in Chittagong? What types of activities can be done at the beach?"
"Is there any museum in Chittagong? What kind of exhibits do they showcase?"
"What historical sites are located in Chittagong city?"
"Are there any adventure activities available in Chittagong for adults?"
"What are the transportation options available for reaching different tourist attractions in Chittagong?"
"What are the opening hours of the Chittagong museum on weekends?"
These sample questions served a vital role in guiding the development of our ontology and ensuring that it was able to address the information needs of our target audience effectively. Defining the types of questions the ontology should answer also facilitated the process of limiting its scope. By focusing on specific categories and sample questions, we were able to avoid unnecessary complexity and ensure that the ontology remained manageable and practical in its implementation.
This approach helped us to prioritize the most essential information and ensure that the

ontology would be readily usable by our target audience.

Step 2: Reusability and Existing Ontologies

The second step in our ontology development process involved considering the potential for reusing existing ontologies. We investigated the availability of existing ontologies related to tourism, specifically focusing on ontologies that might be relevant to the domain of Chittagong's tourist attractions.

2.1 Search for Existing Ontologies

We conducted a comprehensive search for existing ontologies related to tourism and Chittagong. This included exploring online repositories, academic publications, and industry resources.

2.2 Implications of Non-existence

After thorough investigation, we concluded that no existing ontology fully satisfied the requirements of our project, specifically tailored to Chittagong's tourist attractions. We determined that developing a new ontology specifically focused on Chittagong's tourist attractions was the most effective approach to achieve our objectives. While it meant that we would need to develop our own knowledge base from scratch, it also offered the freedom to design an ontology that specifically catered to the unique features and characteristics of Chittagong's tourism landscape.

Step 3: Enumerating Important Terms in the Ontology

3.1 Identifying Relevant Categories

In the third step of developing our ontology for Chittagong's tourist attractions, we focused on identifying and enumerating the key terms that would form the foundation serve as the building blocks of our knowledge base.
In the initial stage of developing an ontology, it is crucial to establish a comprehensive list of relevant terms. At this stage, it is critical to prioritize the inclusion of all potentially relevant terms without focusing on potential overlaps, relationships, properties, or classifications. This comprehensive approach ensures that the ontology encompasses all essential concepts within the chosen domain.
By adopting this inclusive strategy, we avoid prematurely restricting the scope of the ontology and neglecting potentially valuable information. This allows for a more organic

and iterative development process, where refinements and adjustments can be made as the ontology matures.

3.1.1 Identifying Broad Categories:

Specifically, we aimed to encompass the following categories of terms:

Places: Geographic locations within Chittagong, including iconic landmarks, historical sites, natural wonders, and neighborhoods.

Activities: Experiences and events available to tourists, encompassing various types (cultural, adventure, entertainment, etc.) and catering to diverse audiences (families, children, adults).

Accommodations: Lodging options for tourists, ranging from hotels and resorts to guesthouses and homestays.

Facilities: Services and amenities supporting tourism activities, including restaurants, cafes, shops, transportation, restrooms, etc.

Food: Culinary offerings specific to Chittagong, including local dishes, street food, and international cuisines.

Tourism Types: Different classifications of tourism based on the primary motivation and experience sought by visitors.

3.1.2 Listing Specific Terms

Within each category, we identified a diverse range of specific terms, encompassing:

Places: Potenga Beach, Chawkbazar, Double Mooring, Pahartoli, Ethnological Museum, Chittagong Zoo, Kaptai Lake, Foy's Lake, Chittagong War Cemetery.

Activities: Sightseeing Tours, Historical Walks, Shopping, Beach Activities (swimming, sunbathing, water sports), Boat Tours, Hiking, Camping, Kayaking, Children's Playgrounds, Cultural Performances

Accommodations: Hotels (luxury, budget, boutique), Resorts, Guesthouses, Homestays

Facilities: Restaurants, Cafes, Shops, Transportation (taxis, buses, ferries), Tourist Information Centers, Restrooms, Parking Lots

Food: Local Dishes (Chittagong Curry, Halim, Doi), Street Food (Fuchka, Jhalmuri, Chatpoti), International Cuisine

Tourism Types: Cultural Tourism, Entertainment Tourism, Eco-Tourism, Natural Tourism, Adventure Tourism, Religious Tourism.
With this comprehensive and inclusive approach, we have established a strong foundation to construct a robust and informative ontology for Chittagong's tourist attractions.This approach ensures that the ontology captures the full breadth of relevant knowledge and provides a strong foundation for further development and refinement.

Step 4. Defining Classes and Class Hierarchy:

The fourth step in our ontology development focuses on identifying and defining the key classes or concepts related to tourism in Chittagong. Establishing class hierarchy and relationships is an essential step in building a robust and informative ontology.
Defining classes and their hierarchical relationships is a fundamental step in ontology development. It involves structuring the domain knowledge by identifying key concepts and establishing their relationships. Several approaches can be used for this process, each offering distinct advantages and disadvantages. Here, we discuss three main approaches and how we employed a combination of them in our ontology development process:

- **Top-down Approach**

  The top-down approach involves starting with the most general concepts in the domain and progressively specializing them into more specific subcategories. These concepts then serve as superclasses, gradually being specialized into more specific subclasses through refinement and differentiation.However, it can be challenging to anticipate all potential specific subclasses at the initial stages, potentially requiring subsequent adjustments and restructuring.

- **Bottom-Up Approach**

  The bottom-up approach begins with the identification of the most specific and concrete entities within the domain. These entities are then grouped and categorized based on shared attributes and relationships, progressively forming more general classes. However, it can be challenging to ensure that the resulting class hierarchy remains consistent and avoids redundancy or ambiguity.

- **Combined Approach**

  This approach represents a synthesis of the top-down and bottom-up methods. It acknowledges the value of both perspectives, utilizing a combination of starting

with key general concepts and incorporating specific entities identified during the development process. This balanced approach offers a flexible and adaptable strategy, allowing for continuous refinement and improvement as the ontology evolves.

4.1 Our Approach

For our tourism ontology, we opted for a combination approach. We began by identifying the core concepts within the tourism domain, representing them as top-level classes. This involves identifying the most salient and overarching concepts first (top-down), such as "Tourist_place_info" and "Tourism_attraction","Accommodation", and "Chittagong", which serve as foundational pillars for our knowledge representation. These top-level classes are then further specialized into subcategories based on specific characteristics and relationships, incorporating a bottom-up perspective. This combined approach allowed us to achieve a comprehensive and well-organized representation of the domain, capturing both general knowledge and specific details relevant to the tourism industry in Chittagong.
This section describes and defines the class hierarchy developed for the tourism ontology, focusing on Chittagong. The hierarchy aims to provide a structured representation of the domain knowledge, facilitating reasoning, inference, and retrieval of information.

4.2 Top-level Classes

Tourist_place_info: This class represents information specific to tourist places, including descriptions, locations, amenities, and activities.

Accommodation: This class encompasses all forms of lodging available to tourists, such as hotels, resorts, guesthouses, and homestays.

Chittagong: This class represents the city of Chittagong and serves as a superclass for further classifications.

Tourism_Type: This class denotes different categories of tourism based on the primary motivation and experience sought by visitors.

Tourism_Attraction: This superclass encompasses various entities and services relevant to tourist experiences, including activities, facilities, food, rides, and wildlife encounters.

Transport_System: This class represents various transportation options available to tourists within Chittagong.

4.3. Subclasses and Further Classifications:

Chittagong is further classified into two subclasses:

Metropolitan: This subclass encompasses the central urban area of Chittagong.

Non-Metropolitan: This subclass includes areas outside the city center.

Tourism type is further divided into several subclasses that represent specific types of tourism:

Cultural_Tourism: This subclass focuses on experiencing the cultural heritage of Chittagong, including art galleries, historical parks, sites, and museums.

Eco_Tourism: This subclass emphasizes nature-based activities and attractions, including adventure parks, eco-parks, national parks, and wildlife reserves.

Entertainment_Tourism: This subclass focuses on leisure and amusement, including amusement parks, farmhouses, water theme parks, and zoos.

Natural_Tourism: This subclass highlights natural beauty and landscapes, encompassing beaches, aesthetic places, wildlife sanctuaries, and other natural attractions

Tourism_attraction has several subclasses that represent specific aspects of the tourist experience:

Tourist Activities: This subclass includes various activities that tourists can engage, such as sightseeing, adventure sports, cultural events, and shopping.

Network Connectivity: This subclass focuses on the availability and quality of internet and communication services for tourists.

Facility For Tourists: This subclass encompasses services and amenities that cater to tourists, including restaurants, cafes, shops, restrooms, and tourist information centers.

Food For Tourists: This subclass represents various food options available to tourists, including local cuisine, international dishes, and street food.

Rides For Tourists: This subclass includes different transportation options specifically designed for tourist activities and entertainment, such as boat tours, cable cars, and amusement park rides.

Wildlife For Tourists: This subclass focuses on opportunities for tourists to observe and interact with wildlife in controlled environments, such as zoos, wildlife sanctuaries, and guided wildlife encounters.

Transport_system is further classified into four subclasses based on the mode of transportation:

Air_Way: This subclass represents air travel options, including airports and airlines operating within Chittagong.

Water_Way: This subclass focuses on water-based transportation, including ferry services, boat tours, and cruises.

Road_Way: This subclass represents various road-based transportation options, including buses, taxis, and car rentals.

Rail_Way: This subclass encompasses train services operating within Chittagong and its surrounding areas.

By establishing this class hierarchy and further classifications, we create a well-structured and organized representation of the various concepts and entities within the tourism domain in Chittagong.This hierarchy lays the foundation for further knowledge representation and reasoning within the ontology, facilitating information retrieval, planning, and decision-making for tourists and tourism stakeholders.

Step 5: Object Properties in the Tourism Ontology.

Following the identification of key classes, the next step focused on defining object properties that represent relationships between these classes. These properties bridge the gap between concepts, providing a deeper understanding of how elements within the domain interact and connect.The following object properties were added:

Can-be-travelled-by: This property relates a tourist destination to the various transportation options available to reach it, such as buses, trains, cars, bikes, rickshaws, and CNG cabs. Its domain is the class tourism_type and its range is the class transport system.

Has-Accommocation: This property connects a tourist destination with the various types of accommodations available in that location, including hotels and resorts. Its domain is the class Chittagong and its range is the class Accommodation.

Has-Connectivity: This property relates a tourist destination to its network connectivity capabilities, indicating whether the area has good, limited, or no internet access.Its domain is the class tourism_type and its range is the class connectivity.

Has-Activity: This property relates a tourist destination to the various recreational activities available, such as sightseeing, adventure sports, cultural events, shopping, camping, enjoying natural scenery, and observing wildlife. Its domain is the class tourism_type and its range is the class activity.

Has-Facility: This property connects a tourist destination to the amenities and services available for tourists, including restaurants, cafes, shops, restrooms, parking lots, outdoor dining areas, and tourist information centers. Its domain is the class tourism_type and its range is the class facility.

Has-Food: This property represents the various food options available at a tourist destination, including local cuisine, international dishes, street food, and specific snacks like chips and biscuits, fast food, fuchka-chotpoti, and cotton candy. Its domain is the class tourism_type and its range is the class food.

Has-Market: This property indicates whether a tourist destination has a market or shopping area and provides details about it. Its domain is the class tourism_type and its range is the class market.

Has-Place-Info: This property connects a tourist destination to specific information relevant to tourists, including descriptions, opening hours, and ticket fees. Its domain is the class tourism_type and its range is the class place_info.

Has-Ride: This property relates a tourist destination to the specific transportation options designed for tourist activities and entertainment, such as engine boats, kayak boats, speed boats, bumper cars, circus trains, and amusement park rides. Its domain is the class tourism_type and its range is the class ride.

Has-Wildlife: This property connects a tourist destination to opportunities for observing and interacting with wildlife in controlled environments, such as zoos, wildlife sanctuaries, and guided wildlife encounters. Its domain is the class tourism_type and its range is the class wildlife.

Has-Tourist-Place: This property relates a tourism_type to the specific tourist destination within Chittagong.

Defining object properties within the Chittagong tourism ontology establishes a comprehensive network of relationships between different entities, facilitating efficient knowledge representation and retrieval for all aspects of tourism in the city. Through these object properties, the ontology is enriched with valuable semantic connections between concepts, enabling more sophisticated reasoning and information retrieval within the

domain of Chittagong tourism.

5.1 Domain and Range

In semantic modeling, an object property possesses well-defined domain and range constraints.The domain specifies the class of entities that can act as the subject of the property, while the range specifies the class of entities that can be the object of the property. For example, the domain of "can-be-travelled-by" is "tourism_type" and the range is "transport_system". This implies that only instances falling within the "tourism_type" class are eligible to act as subjects of this property, and conversely, only instances belonging to the "transport_system" class can assume the role of objects.
In addition to object properties, knowledge representation systems also employ data properties to represent associations between entities and literal values. Similar to object properties, data properties are associated with a data type that specifies the type of value they can hold.For example, the data property "Contact_number" might have a data type of "string," indicating it can only store textual data representing phone numbers.This ensures the semantic validity and consistency of the data associated with entities within the ontology.

Step-6: Data Properties in the Chittagong Tourism Ontology

Building upon the previously defined classes and object properties, this section describes the data properties within the Chittagong tourism ontology. These properties represent relationships between individual entities and data literals, providing specific details and characteristics for various elements within the domain.

Here's a breakdown of the data properties used:

Contact-Number: This data property stores the phone number associated with an entity, such as a tourist place or accommodation facility. Its data type is string.

Address: This data property specifies the location address of an entity, including street address, postal address, or geographic coordinates. Its data type is string.

Description: This data property provides a textual description of an entity, offering further information about its features, history, or significance. Its data type is string.

Open-Hour: This data property stores the opening hours of an entity, such as a tourist place Its data type is string.

Parking-Fee: This data property indicates whether a location charges a parking fee or not. Its data type is boolean.

Ticket-Fee: This data property indicates whether an entry fee is required to access a tourist attraction or place. Its data type is boolean.

Rating: This data property represents the average rating assigned to an entity by users or guests.

Its data type is decimal, allowing for fractional values. By incorporating these data properties, the Chittagong tourism ontology becomes a comprehensive and informative resource, empowering tourists with the knowledge they need to plan and enjoy their travel experiences.

Step-7: Populating the Ontology with Instances and Relationships

The seventh stage in our ontology development process involves populating the framework with instances or individuals related to tourism in Chittagong. Establishing the relationships between these instances and their corresponding classes form a cornerstone of ontology construction.

7.1 Defining Instances in Ontological Context

Within the realm of ontology, an instance is a specific, concrete object of a class or concept within the ontology's knowledge domain. It represents an individual entity or object that belongs to a certain category or concept or class. For example, within our ontology, entities such as "car" and "bus" are instances associated with the class "Transport_System," exemplifying the real world application of this conceptual framework. Instances serve as concrete data points or examples that adhere to the conceptual structures and relationships defined by the ontology. This facilitates the representation of real-world entities within a formalized knowledge framework.

7.2 Example of Instance Hierarchy within Accommodation

To illustrate the concept of instances within our ontology, let's consider the class "Accommodation," which further comprises subclasses like "Hotel" and "Resort." Each of these subclasses can then contain its own set of specific instances, such as "aristos-boutique-hotel" and "hotel-saint-martin-limited." In this example, "aristos-boutique-hotel" and "hotel-saint-martin limited" are individual entities belonging to the subclass "Hotel,"

and “suite-lake-view” and “super-deluxe” are instances of the ”Resort” subclass, ultimately stemming from the parent class ”Accommodation.”

7.3 Quantitative Scope of Our Ontology

Currently, our ontology encompasses a total of 418 distinct instances distributed across 51 defined classes. This demonstrates the comprehensiveness and richness of the knowledge base, encompassing a diverse range of entities relevant to tourism in Chittagong. The inclusion of instances and their relationships within the ontology significantly enriches its representational power and enables the capture of real-world nuances within the formalized knowledge framework. This step paves the way for further development and utilization of the ontology for various applications within the domain of tourism.

Step-8:The Reasoning of ontology

In the eighth step of ontology development, the application of reasoning assumes a pivotal role in safeguarding the accuracy and coherence of the ontology. This essential process, facilitated by the utilization of HarmiT 1.4.3.456, a highly optimized OWL 2 reasoner, is instrumental for logical reasoning within our ontology. The selected reasoner critically contributes to the evaluation of logical coherence, ensuring consistency, and pinpointing potential contradictions within the ontology, thereby establishing a robust and dependable knowledge representation.
The process of reasoning in ontology involves drawing logical inferences, making deductions, and deriving conclusions by applying formal logic to analyze the defined relationships, axioms, and rules within the ontology. In essence, this process enables the extraction of new information or relationships from the existing knowledge structure encapsulated within the ontology.

Step-9: Query-Based Evaluation Assessment

In the ninth step of ontology development, the imperative role of querying emerges as a foundational process for the evaluation and retrieval of information from the ontology. The use of querying serves as a robust mechanism to evaluate the ontology by systematically acquiring specific information pertaining to tourist attractions, aligning with the predefined criteria embedded in the ontology.
This meticulous querying process forms an integral component of the overarching evaluation strategy, contributing to a nuanced understanding of the ontology’s performance and adherence to specified criteria.

3.5 CONCLUSION

The journey outlined in this methodological framework charts a course for a comprehensive and user-centric tourism ontology for Chittagong. By meticulously weaving together the threads of domain analysis, user-centered design, and data-driven knowledge organization, we have crafted a roadmap that promises to empower tourists, enrich their experiences, and contribute to the sustainable development of Chittagong's tourism industry.

This ontology, far from being a static map, is a dynamic ecosystem, constantly evolving and adapting to the ever-changing landscape of Chittagong. Its robust framework allows for future integration with other knowledge bases, opening doors to exciting possibilities like personalized recommendations and real-time information updates.Ultimately, this methodological journey is not merely about creating a digital tool; it is about unlocking the hidden treasures of Chittagong.In doing so, we pave the way for a future where Chittagong thrives as a vibrant and welcoming destination.

Chapter 4

Results and Discussions

4.1 INTRODUCTION

Motivated by the desire to enhance the tourist experience in Chattogram, Bangladesh, this thesis explores the potential of semantic web technologies to improve destination exploration. We propose the development of a knowledge base encompassing tourist attractions, their attributes, amenities, and accessibility information. This knowledge base, constructed using ontologies, aims to provide a semantically rich and readily accessible resource for visitors, fostering a more personalized, connected, and inclusive tourism experience.The core of our approach lies in the meticulous construction of ontologies, formal conceptual frameworks that capture the essence of Chattogram's popular tourist destinations. These ontologies facilitate effective information organization, knowledge representation, and data storage, retrieval, and reasoning within the tourism domain. Through a rigorous ontology-building process, we identify key concepts, relationships, and attributes pertinent to the Chattogram tourism landscape. This structured representation forms the bedrock of the knowledge base, ensuring information accuracy, consistency, and interoperability.

Data collection for the thesis presented inherent challenges, although diligent efforts were undertaken to assemble a comprehensive dataset. Diverse sources were utilized, including web based resources, YouTube video analysis, tourist reviews across various social media platforms, and direct data collection at tourist locations. This multifaceted approach provided a rich tapestry of data encompassing geographical information, open hours, ticket pricing, accessibility considerations, available amenities, accommodation options, and historical context, painting a complete picture of Chattogram's tourism

landscape. Through the application of semantic reasoning techniques, the resulting system possesses the capability to dynamically respond to complex user queries, tailoring its responses to individual needs and preferences.

4.2 RESULTS

4.2.1 GENERAL RESULTS

Ontology Development

Our knowledge base currently encompasses extensive information on over 30 tourism destinations in Chattogram, catering to a diverse range of tourism types. These types include historical tourism, natural tourism, religious sites, museums, cultural tourism, and eco-tourism, among others. To facilitate efficient access and retrieval of this information, we have developed a domain ontology specifically tailored to tourism destinations within Chattogram. This ontology defines fundamental concepts such as "accommodation," "tourism_type," "tourist_attraction," and "transport_system." The relationships between these concepts are established through object properties, including "has-facility," "has-activity," "has-food," and "has-ride." Additionally, data properties specific to each concept are defined, such as "open-hour," "entry-fee," "parking-fee," and "description." This comprehensive and structured knowledge representation enhances the usability and utility of our tourism information platform.

Semantic Representation

To ensure the consistency, accuracy, and interoperability of data, thereby facilitating efficient knowledge sharing and integration, we employed semantic web-based technologies for machine understandable information representation. Specifically, we utilized Protégé 5.6.3 to construct a formal, machine-readable knowledge representation of the domain in the form of an ontology. This ontology, comprising concepts, relationships, and rules, empowers computers to comprehend and reason about the domain.

Reasoning and Query Answering

The system integrates reasoning techniques to effectively address intricate queries formulated by users. This empowers tourists to retrieve highly tailored information that aligns with their specific criteria, encompassing accessibility needs, preferred activities and attractions, and desired travel styles. This intelligent feature augments the user

experience and fosters informed decision-making. To achieve this, we employed HarmiT 1.4.3.456, a robust reasoning engine, empowering the system to leverage its knowledge base, logic, and experience to analyze information and deliver pertinent responses. Additionally, we integrated SPARQL, a query language specifically designed for RDF data, to implement reasoning techniques grounded in Description Logic, further enhancing the system's capacity to address complex user queries. To facilitate user-centric information retrieval, we developed a sophisticated query interface that empowers users to articulate their preferences and requirements with precision. This interface grants users the ability to filter results based on diverse criteria, including location, category, accessibility features, and accommodation facilities, ensuring a personalized and adaptable experience.

4.2.2 SPECIFIC RESULT

Several significant and concrete outcomes emerged from this research.

- The present work has established an ontology comprising total 51 classes and 418 individuals. Each individual is associated with its corresponding class via the object property. Furthermore, detailed descriptions of select classes are provided through the utilization of data properties. Illustrative examples of these descriptions are presented subsequently:

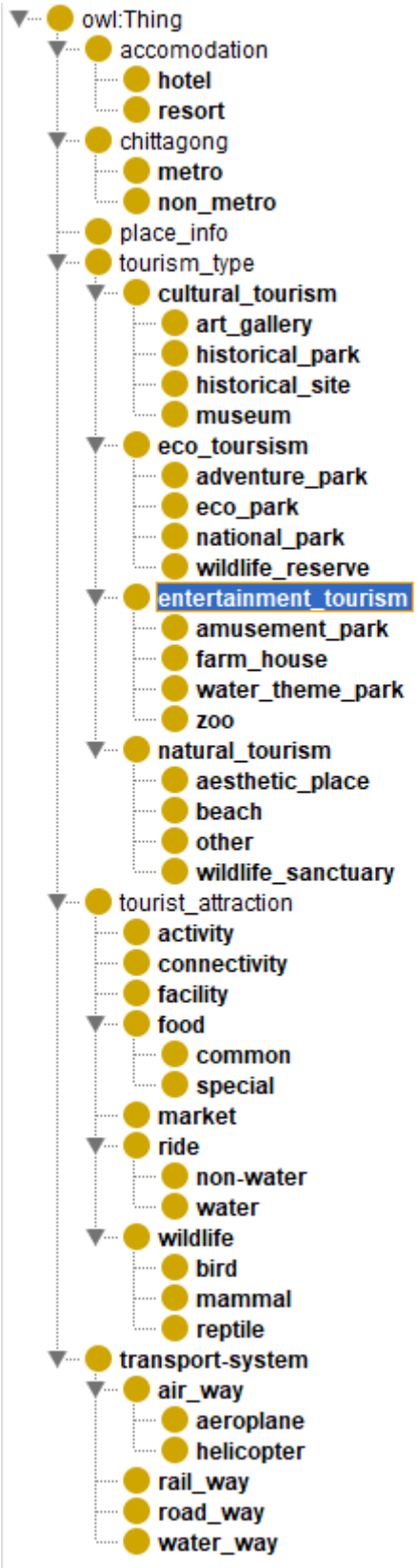

Fig. 4.1. Tourism Ontology Classes

In Fig. 4.2 The ontology employs object properties to formalize binary relations between individual entities. These properties capture asymmetric dependencies,

unlike data properties, which merely associate instances with uninterpreted data elements.

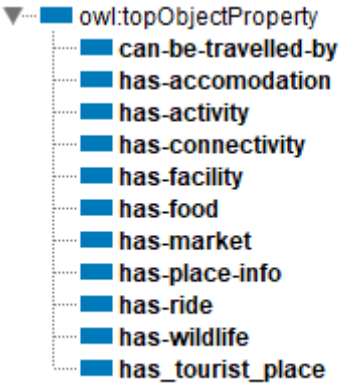

Fig. 4.2. Tourism Ontology Object Properties

In Fig. 4.3 Data properties serve as a fundamental mechanism for establishing associations between individual entities (instances of classes) and concrete data values. These values encompass a diverse range of data types, including strings, numerical quantities, temporal constructs, and web addresses.

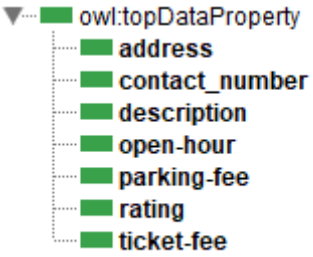

Fig. 4.3. Tourism Ontology Data Properties

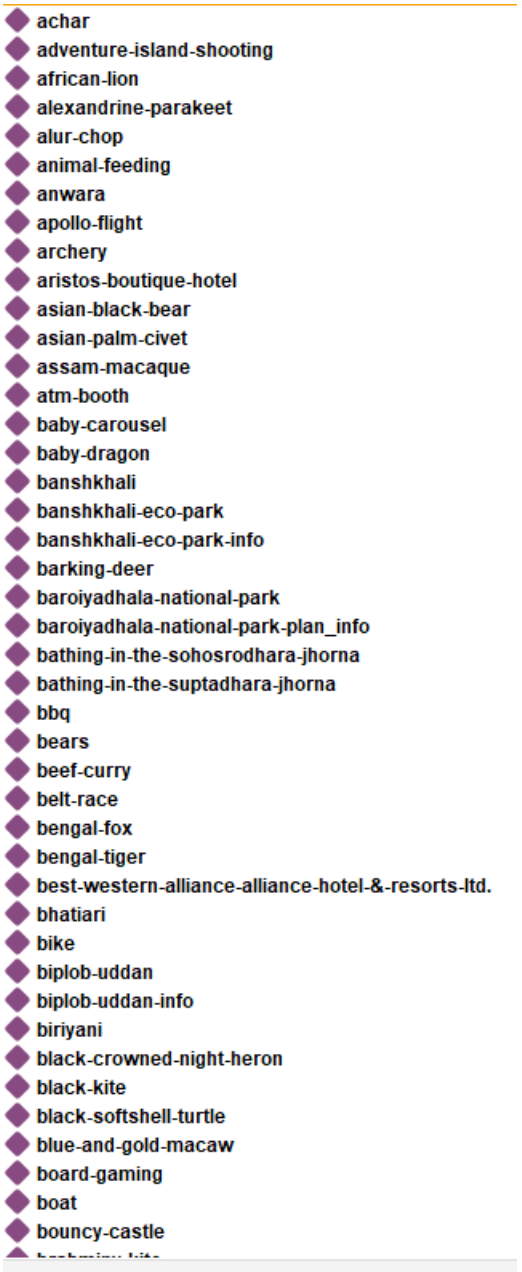

Fig. 4.4. Individuals of our ontology

In Fig. 4.4 Within the domain of our tourism ontology, distinct individuals act as representations of specific entities or objects. Each individual within this ontology is characterized by the possession of one or more defined property values.

- In the present section, we introduce an interactive graph visualization tool for exploring the spatial distribution of tourist attractions in Chattogram. This tool facilitates the exploration of these locations through information-rich pop-up windows, enhancing user comprehension and enabling informed decision-making. By employing this visualization, users can gain a comprehensive visual understanding of the tourism landscape within Chattogram.

  In Fig 4.5, Within the context of this work, we present the asserted view of a Chittagong tourism ontology. This view comprises explicitly defined statements and relationships, manually entered by us. The asserted view adopts a tree structure to visually represent the class hierarchy and facilitate comprehension of inter-class relationships.

  In Fig 4.6 & 4.7, This contribution presents the asserted-view of two core concepts, tourism_type and tourist_attraction, as captured within the developed ontology. These visualizations facilitate access to the encoded domain knowledge, enabling users — particularly tourists — to navigate and comprehend the structure and relationships within the system.

  The Fig 4.8 depicts the inferred view of the Chittagong Tourism Ontology, generated through automated reasoning processes applied to the explicitly asserted axioms. This visualization facilitates tourist access to implicit knowledge derived from the domain model, enhancing their understanding of the intricate relationships within the system.

Fig. 4.5. Asserted View of owl visualization

Fig. 4.6. Asserted view of tourism_type class

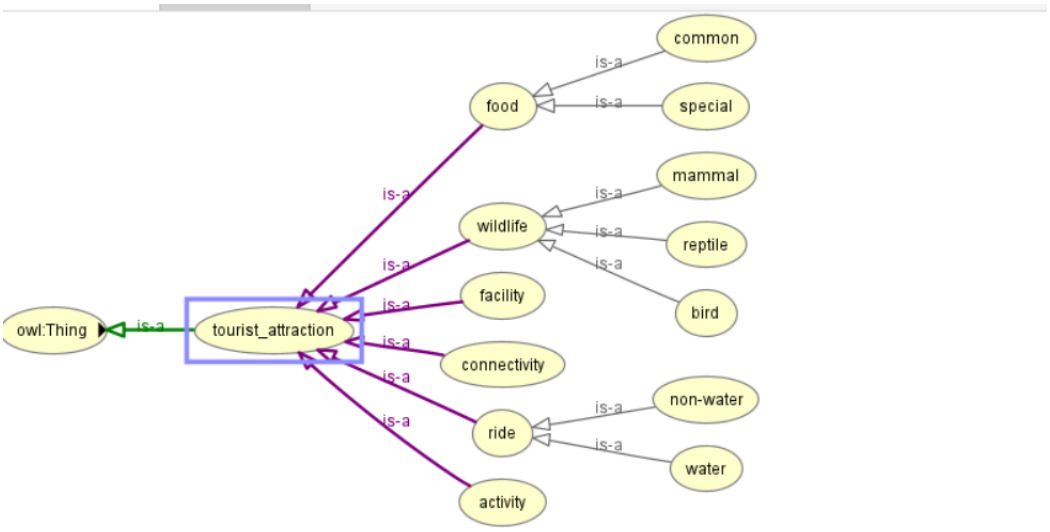

Fig. 4.7. Asserted view of tourist_attraction class

Fig. 4.8. Inferred view of owl visualization

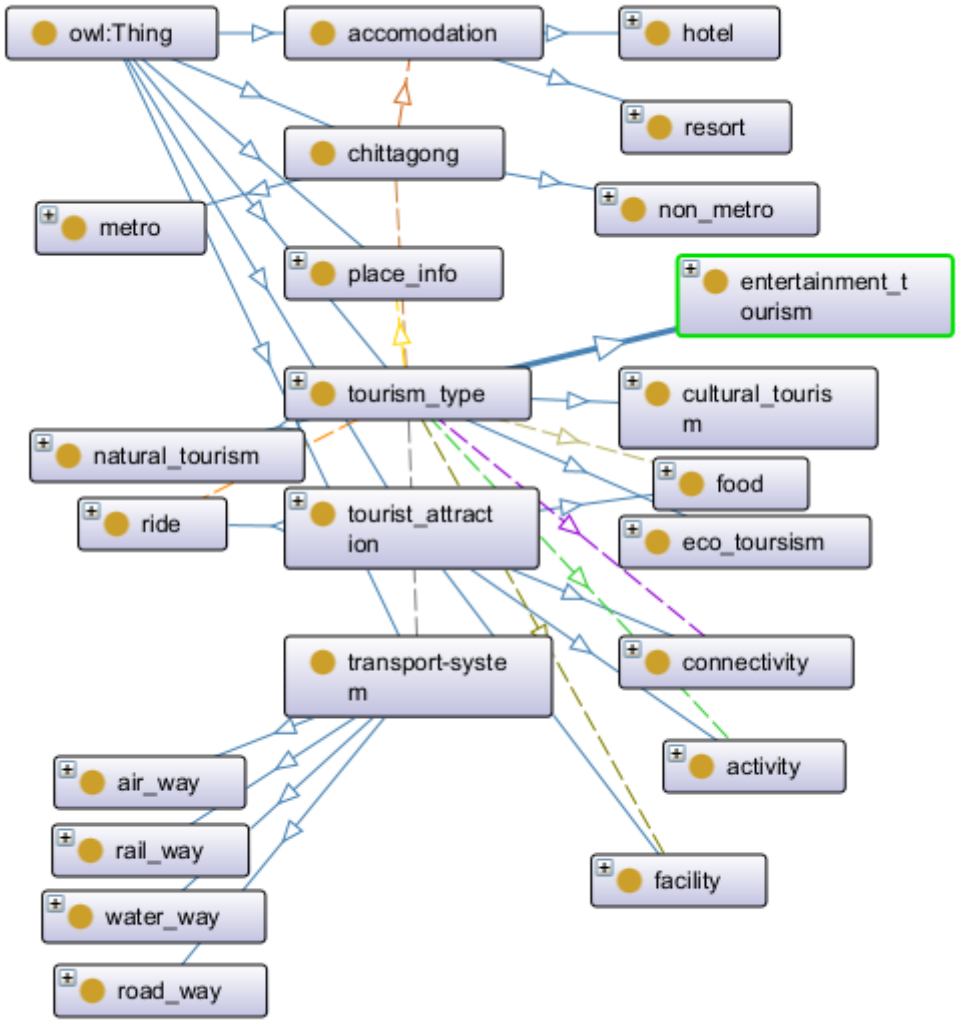

Fig. 4.9. Ontograf of our Ontology

In Fig 4.9 OntoGraf leverages a graphical representation of the domain ontology, employing nodes as surrogates for concept classes and edges to signify the interrelationships between these classes. This visual language facilitates information retrieval for users, as exemplified by a tourist seeking details about tourism opportunities within the Chittagong district. The user can readily navigate the detailed ontology view presented by OntoGraf to acquire the desired information.

- This section addresses the challenge of answering tourism-related queries within the context of the thesis. We demonstrate the effectiveness of our dataset in retrieving information about Chattogram tourism through the implementation of SPARQL queries. The section presents a comprehensive list of queries alongside their execution using SPARQL and the corresponding results obtained. To facilitate this process, we employed the Jena Fuseki server. We provide example queries below to illustrate the capabilities of our approach.

```
SELECT  ?places
WHERE
  { ctg:potenga ctg:has_tourist_place ?place

BIND(strafter(str(?place), str(ctg:)) AS ?places)


}
```

Fig. 4.10. SPARQL query Q-1

	places
1	Naval
2	butter-fly-park
3	patenga-sea-beach

Fig. 4.11. SPARQL query answering Q-1

Q-1) what are the tourist places in Potenga?

In Q-1 For a tourist seeking information about tourist places in Potenga, a comprehensive approach would be adopted. Initially, a catalog of tourist places in chittagong would be compiled. Subsequently, this inventory would be analyzed to identify those places with specific characteristics analogous to the places offerings of potenga. Finally, these identified places would be presented as the recommended answer to the tourist's query.

```
SELECT  ?Commonfoods
WHERE

  { ctg:biplob-uddan ctg:has-food ?food
BIND(strafter(str(?food), str(ctg:)) AS ?Commonfoods)

}
```

Fig. 4.12. SPARQL query Q-2

	Commonfoods
1	drink
2	fast-food
3	fuchkaa-chotpoti
4	jhaal-muri
5	samosa
6	singaara

Fig. 4.13. SPARQL query answering Q-2

Q-2). What are the common foods of biplob-uddan?

In Q-2 For a tourist seeking information about common foods in Biplab Udyan, a comprehensive approach would be adopted. Initially, a catalog of commonly available Bangladeshi food items would be compiled. Subsequently, this inventory would be analyzed to identify those dishes with specific characteristics analogous to the culinary offerings of Biplab Udyan. Finally, these identified food items would be presented as the recommended answer to the tourist's query.

```
11  SELECT   ?hotels
12  WHERE
13
14    { ctg:potenga ctg:has-accomodation ?hotel .
15
16  BIND(strafter(str(?hotel), str(ctg:)) AS ?hotels)
17
18  }
```

Fig. 4.14. SPARQL query Q-3

	hotels
1	brisa-marina
2	hotel-belmond-city

Fig. 4.15. SPARQL query answering Q-3

Q-3). What hotels are there in potenga?

In Q-3 Tourist inquiries regarding hotels within the Patenga vicinity often lead to search results encompassing the broader Chattogram area. To provide an accurate and relevant response, it is crucial to identify and compare options situated specifically within Patenga, ensuring the recommended establishments cater directly to the tourist's intended location.

```
9   SELECT  ?nonwaterrides
10  WHERE
11
12    { ctg:chattogram-shishu-park ctg:has-ride ?ride
13  BIND(strafter(str(?ride), str(ctg:)) AS ?nonwaterrides)
14
15  }
```

Fig. 4.16. SPARQL query Q-4

	nonwaterrides
1	
2	bumper-car
3	coffee-cup
4	family-roller-coaster
5	family-boat
6	car-racing
7	circus-train
8	coin-game
9	crazy-car
10	horse-racing
11	jett-coaster
12	merry-go-round
13	paratrooper
14	zebra-racing

Fig. 4.17. SPARQL query answering Q-4

Q-4). What are the non water rides in chattogram shishu park?

In Q-4 To retrieve information about non-water rides available within Chittagong Shishu Park, a user can formulate a SPARQL query specifically targeting non-water ride classes within the ontology. This query would then perform a semantic comparison between the ontology's non-water ride instances and those associated with Chittagong Shishu Park. The resulting matches, representing relevant non-water rides available in the park, would be presented to the user.

```
SELECT  ?specialfoods
WHERE

  { ctg:patenga-sea-beach ctg:has-food ?food


BIND(strafter(str(?food), str(ctg:)) AS ?specialfoods)


}
```

Fig. 4.18. SPARQL query Q-5

	specialfoods
1	crab-fry
2	fuchka-chotpoti
3	jhal-muri
4	piyaju
5	achar

Fig. 4.19. SPARQL query answering Q-5

Q-5). What are the special foods in Patenga sea beach?

In Q-5 To ascertain the availability of specialty foods at Patenga Sea Beach, a user can formulate a SPARQL query targeting the "special food" concept within the ontology. This query would execute a semantic search across all instances of special food, subsequently filtering them based on their association with Patenga Sea Beach. The resulting matches, representing specialty foods available at the beach, would be presented to the user.

```
9   SELECT  ?rides
10  WHERE
11
12    { ctg:patenga-sea-beach ctg:has-ride ?ride
13
14
15  BIND(strafter(str(?ride), str(ctg:)) AS ?rides)
16
17
18  }
```

Fig. 4.20. SPARQL query Q-6

	rides
1	horse
2	speed-boat
3	sea-beach-fat-bike

Fig. 4.21. SPARQL query answering Q-6

Q-6). What types of rides are available in patenga sea beach?

To fulfill a user's query regarding rides available at Patenga Sea Beach, the system would leverage a SPARQL query targeting the ontology's "ride" class and its associated properties. This query would first retrieve all instances of the "ride" class within the ontology. Subsequently, it would employ property constraints, possibly related to location or specific attributes, to filter and identify those rides associated with Patenga Sea Beach. Finally, the system would present only the matching ride instances to the user, representing the rides available at the desired location.

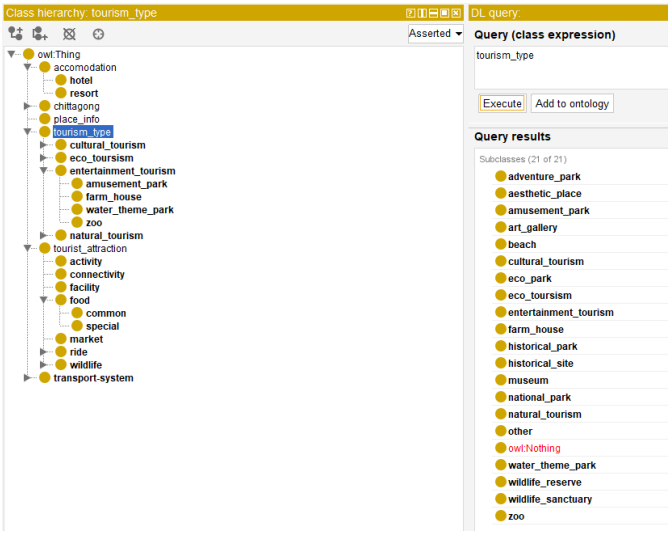

Fig. 4.22. DL query view of tourism_type in our ontology

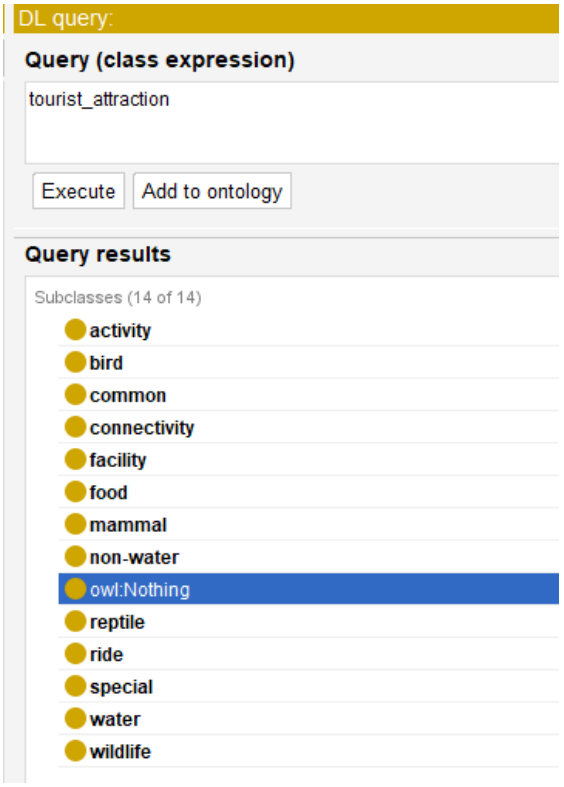

Fig. 4.23. DL query view of tourist_attraction in our ontology

Employing the expressive capabilities of DL queries, users can efficiently explore the hierarchical structure of the ontology in a targeted manner. In Fig 22 & 23, a tourist interested in understanding the diversification of tourist attractions and tourism types within the knowledge base could utilize a DL query focused on the "tourist_attraction" and "tourism_type" classes. The query would then yield a set of identified subclasses, representing specialized categories within these broader classifications. This detailed view of the ontology's hierarchy would empower the user to navigate and engage with

relevant information more effectively.

These specific results demonstrate the practical view of semantic web technologies in enriching tourism experiences in Chattogram. The constructed knowledge base and its associated tools equip key actors - tourists, tourism businesses, and local authorities - to leverage this valuable data for the sustainable development and promotion of Chattogram's tourism landscape.

4.3 DISCUSSION

The burgeoning field of semantic web technologies presents significant opportunities for the tourism industry in Chattogram. This study presents the development of a focused ontology for the domain of tourism within Chittagong district. Leveraging the inherent structure and relationships captured within the ontology, targeted information retrieval for tourists exploring the region can offer significant advantages over general search engines. Firstly, the domain-specificity of the ontology restricts search results to entities and concepts directly relevant to tourism in Chittagong, minimizing the presence of irrelevant information that often plagues general search queries. Secondly, the ontology's representation of relationships between domain entities enables the system to interpret the semantic intent behind a tourist's query, exceeding the limitations of traditional keyword matching employed by general search engines. Finally, the structured and categorized organization of information within the ontology facilitates intuitive natural language queries for tourists, further enhancing the user experience compared to unstructured general search results. The efficacy of ontology-driven information retrieval systems is intrinsically linked to the quality of the factual and rule-based representations of the interrelationships between concept classes within the underlying ontology.

This democratization of knowledge enhances traveler experiences by fostering informed decision-making through readily accessible information. Furthermore, intelligent query answering systems personalize catering to individual needs and preferences. This data-driven approach promotes ethical and sustainable tourism practices by ensuring satisfying experiences for each visitor, thereby attracting diverse tourist groups. Spatially-aware insights empower travelers to efficiently navigate and discover attractions, facilitating well-informed travel plans. This user-centric approach fosters deeper engagement with the city's rich tapestry and encourages further exploration.

4.4 SUMMARY

This study leverages the potential of semantic web technologies to create a comprehensive knowledge base encompassing over 30 tourist destinations in Chattogram. This readily accessible resource furnishes travelers with detailed information on a diverse spectrum of topics, ranging from historical landmarks to natural wonders. Intelligent query response mechanisms guarantee a fulfilling travel experience for each visitor. While limitations exist, primarily concerning data accuracy and reasoning capabilities, the future holds immense potential. Further research and development can refine this innovative approach, paving the way for a dynamic and data-driven tourism industry in Chattogram. This semantic web-driven methodology unlocks exciting possibilities, ensuring Chattogram's continued allure for generations to come.

Chapter 5

Conclusion And Future Works

5.1 CONCLUSION

This thesis, founded on a dedication to user pleasure and long-term tourist growth, makes an important contribution to the discussion of Chittagong's cultural, historical, and natural resources

An investigation was undertaken into Chittagong District's tourism environment to enhance visitor experiences and promote seamless information access.

The rich cultural, historical, and natural resources of Chittagong were recognized, positioning it as a potential tourism destination

Shortcomings in current information-sharing methods were identified, lacking a comprehensive, user-friendly, and engaging experience for modern tourists

The study trip commenced by acknowledging challenges faced by travelers due to the absence of a structured information framework, resulting in fragmented comprehension and lost inquiry opportunities.

A methodical approach was implemented, starting with thorough data preparation, navigating administrative divisions, and identifying significant tourism locations.

A multi-sourced data collection process was embraced, incorporating information from government websites, Wikipedia, local insights, and internet resources to supplement

the ontology.

A comprehensive tourism-specific ontology was developed, carefully addressing the changing demands of Chittagong's tourists, residents, and newcomers through domain selection, scope specification, and identification of pertinent question types.

Object properties were utilized as the ontology's semantic backbone to foster meaningful interactions between various tourism-related items.

Data attributes were integrated to add specificity, providing travelers with essential information for identification, comprehension, planning, and decision-making.

The ontology's completeness and user-centric nature were ensured by including attributes such as phone numbers, locations, descriptive narratives, and ratings.

As we conclude, this thesis successfully achieved it's objective by creating a comprehensive and user-centric tourism-specific ontology for Chittagong District, improving the availability, accessibility, and customization of information for tourists.

5.2 CONTRIBUTION OF THIS THESIS

The fulfillment of the objectives outlined in my thesis is substantiated through the realization of its intended contributions. The major contributions of the thesis are:

This thesis's fundamental and overarching contribution is the development of a tourist ontology adapted to the distinct traits and attractions of Chittagong District. This ontology functions as a structured and semantically rich framework for information about diverse tourist destinations, cultural events, historical places, and district-specific data.

A significant contribution is the creation of a structured framework within the ontology, which allows for specialized research for passengers. The technology helps tourists align their preferences with available options by categorizing attractions and cultural events,

boosting their capacity to create and personalize their trip experiences.

The proposed ontology enhances the traveler's experience by efficiently filtering and presenting content based on preferences, ensuring a more engaging exploration with reduced frustration from irrelevant search results.

The ontology enhances vacations by offering interactive guidance on routes, transportation, and accommodations, simplifying trip planning for visitors.

The thesis prioritizes practicality by rigorously evaluating the ontology's usability, accuracy, and effectiveness in addressing tourist challenges in Chittagong District, providing valuable insights for refinement and real-world applicability validation.

Finally, the thesis aims to contribute to the long-term prosperity of the Chittagong District tourism business by fullfilling the objective of the study. The research intends to stimulate informed exploration by providing tourists with a robust and user-friendly information system, improving the link between visitors and the district's unique offers. This, in turn, has the ability to boost the region's economic development by expanding its tourism sector.

5.3 FUTURE WORKS

While this thesis represents a big step forward in improving the Chittagong District's tourism information landscape through the construction of a specialized ontology, there are various options for future exploration and refinement. The following are some prospective future research and development directions:

- To keep the ontology current and up to date, ongoing efforts should be made to broaden its coverage. This entails the continuous inclusion of new tourist locations, cultural events, and pertinent data to keep up with the changing landscape of Chittagong District and to broaden its coverage to include the entire Chittagong Division.

- Future work should prioritize the incorporation of user recommendations and preferences, resulting in incremental improvements that increase the usability and usefulness of the ontology.

- It should be considered to create a user interface that connects easily with the ontology. A user interface would allow for easy engagement with tourism information, interactive elements, and real-time changes.

- Future efforts should investigate the implementation of linguistic support inside the ontology and its user interface to cater to a wide audience of tourists. This would entail translating information, interface elements, and interactive features into other languages in order to provide a more inclusive and user-friendly experience for visitors from diverse linguistic backgrounds.

- Exploring the possibility of additional divisions or regions in Bangladesh adopting a similar ontology model could be a useful topic for future research.

Finally, the future works indicated here give interesting potential for continuous research, development, and collaboration. By adopting these paths, academics can continue to develop and expand the ontology, assuring its continuous relevance and impact on the Chittagong Division tourist landscape and possibly beyond.

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