CHAPTER 7
Applications of Research Findings

7.1 Introduction

This chapter discusses the applications of Subgraph Isomorphism in the present research. Graph matching uses structured information and used in various areas which include structure identification in biological networks, chemistry, document identification, social media networking, image processing, etc. Excluding some areas, graph matching algorithms takes exponential time for matching. Similarly for subgraph isomorphism where, part of the graph is to be matched with another graph or dataset of graphs, this technique is used. In this case also it is very difficult to identify the part of the main graph where efficient algorithms are required for matching. In this way, small graphs can easily be compared but in case of large graph algorithms take exponential time for comparison.

7.1.1 Database

A database is a collection of data that is organized in accordance with the data that is stored and which has to be retrieved [116]. The database management system (DBMS) is the software that interacts with end users, applications, and the database itself to capture and analyze data. A general-purpose DBMS allows the definition, creation, querying, update, and administration of databases. Database Management systems are used in order to manipulate the database. Data entries are governed by database.

Database languages

Database languages are special-purpose languages, which allow one or more of the following tasks, sometimes distinguished as sublanguages:

Data control language (DCL)

It controls access to data. Examples of DCL commands include:

- GRANT to allow specified users to perform specified tasks
- REVOKE to cancel previously granted or denied permissions
Data definition language (DDL)

It defines data types such as creating, altering, or dropping and the relationships among them. Data manipulation language (DML) – performs tasks such as inserting, updating, or deleting data occurrences. Data definition language (DDL) and the Data manipulation language (DML), and may include CONNECT, SELECT, INSERT, UPDATE, DELETE, EXECUTE, and USAGE.

Data query language (DQL)

It allows searching for information and computing derived information. The commands of SQL that are used to retrieve data from the database are collectively called as DQL. So all Select statements come under DQL.

1. Hierarchical database

A hierarchical database model is a data model in which the data are organized into a treelike structure. The data are stored as records which are connected to one another through links. A record is a collection of fields, with each field containing only one value. The type of a record defines which fields the record contains.

2. Network Database

A network database is a type of database model wherein multiple member records or files can be linked to multiple owner files and vice versa.

3. Relational Database

A software system used to maintain relational databases is a relational database management system (RDBMS). Virtually all relational database systems use SQL (Structured Query Language) for querying and maintaining the database.

4. Object Oriented Database

An object database is a database management system in which information is represented in the form of objects as used in object-oriented programming. Object databases are different from relational databases which are table-oriented. Object-relational databases are a hybrid of both approaches.

5. NoSQL

NoSQL is not literally “no SQL”. They are non relational data stores. They are tremendously useful in working with large databases. They are designed for multiple varieties of models, including key-value, document, columnar and graph
formats. Here the data is placed according to the table formed and thus a schema is designed before the database is built. Many NoSQL stores compromise consistency (in the sense of the CAP theorem) in favor of availability, partition tolerance, and speed. Relational databases rely on tables, columns, rows, or schemas to organize and retrieve data. In contrast, NoSQL databases do not rely on these structures and use more flexible data models. There are different types of NoSql databases like key-value data store, document store, wide column, graph store.

7.1.2 Applications

Many applications are necessary for gaining some basic information about a graph by comparing one object with another object.

Examples:

In chemical structure, 2D graph represents vertices and the pair of bonded atoms represents edges. 3D graph representation is different from 2D chemical graph. In 3D graphs, edge indicates geometric distance between atoms.

Different areas of applications are discussed below:

A. Computer Science

1. Database design
   Since graph provides fast implementation process using different components. Graph structure has a vital role in database design.

2. Software Engineering
   In software engineering, graph has many applications:
   
   Data Flow Diagram is used to present the data flow in requirement specification.
   
   In the design phase, the relationship between various modules can be shown in graphical form.
   
   During testing, complete control flow of programme, i.e. a sequence of instruction execution is addressed using directed graphs.

Entity Relationship diagrams.

3. Network System

   In networking different areas are considered for analyzing graph theory.
Advantages of graph based representation:

- Provides various points of views
- Simplifies the problem
- Provides more specific definition

Advantages of network theory:

- Provides a set of techniques for analysis of a graph
- Represents graphs for application of network theory

**Graph purpose in mathematics:** Mathematicians define operations for analyzing and manipulating graphs also have developed constructive theorems.

**Network’s purpose in physics:** Physicist describes an algorithm that gives simpler values by compressing the information available in the network.

**B. Computer Hardware**

1. The compiler uses graph coloring algorithms for register allocation
2. Analysis of model is very useful
3. Addressing the sequence of execution of an instruction
4. Allocation of resources

**C. Data structure**

1. Efficient data organization
2. Calculation of minimum cost tree
3. Reducing data retrieval times
4. Provides link structure in websites

**D. Image processing**

1. Determines boundaries of the picture while segmentation
2. Determines distance transformation of the pixels
3. Calculates the distance between the interior pixels

**E. Data mining**

1. Represents the relational aspect of data
2. Subgraph isomorphism, subgraph categories, mining measure, solution methods and graph invariants are the theoretical based approach of graph

**F. Operating system**

1. represents system process in graphical form
2. provides efficient solution to job scheduling
3. useful in resource allocation in solving execution of CPU problems

G. Website designing
1. Used for searching and discovery of community
2. Represents directed graph in evaluation of web site and link structure
3. Useful in detection of all linked components

7.1.3. Web Browsing of the User’s Behavior

One of the applications that the researcher wants to discuss here is the web browsing of the user’s behavior.

In today’s business world, the technology specially, the internet is playing very important role. Every business can be easily published to its customers through the Web Application, which is one of the important connecting links between the organization and its stakeholder’s specifically customers. Web applications are widely accepted and used by the organizations to let customers know about the organization, submitting demand for their requirements and for so many purposes [117]. But, only developing a web application is not the help in getting success, rather sophisticated web application, which provides an easy navigation, easy interaction and complete set of usability, is very important. Such web applications can be developed by tracking the user’s behavior over the web application and accordingly providing the functionality which matches with the user’s expectations.

Web Application is a program developed for clients to connect to the server, by running it into Web browser which consists of dynamic web pages and provides easy and quick access to the web resources of the organizations [118]. Web Application is a channel through which the clients that are customers in the business model interact with business organizations. There is rapid change in the business model over the years, it has transformed into a consumer oriented market from product oriented market. This consumer oriented market model has forced the sophistication to be brought into the web based platforms; specifically which attracts the customer and which helps in growing the business with transformed model.

The most appropriate systems are those which have good navigation and help the customer to easily find the contents and functionality required at a point of time.
Frequently, the user’s behavior history matches or relates to the users present behavior in the web based systems[119]. So, if we could manage to find and track the users past behavior in web based systems, that will help for customers to predict the user’s behavior navigation which will help to navigate more faster to the user requirements. So, it is important for gaining the customer attention, to provide sophisticated web applications.

There are many systems which are proposed and implemented this idea, but every system is suffering from one or more flaws which are given in the literature. Here, the researcher has proposed the idea for tracking a user’s behavior with the help of a proposed subgraph isomorphism algorithm. Subgraph Isomorphism is the technique of comparing the similarity between two graphs based on data represented by two graphs.

Finding client’s interests is an extremely essential assignment for giving customized benefit of electronic trade. A well-known approach is to create client profiles from their browsing behaviour. It is a concept that constructs a profile of customers based on their web surfing recorded by the personal computer. Based on the web surfing, personal services are conveyed on their profile and this can be then applied to news recommendation and personal services.

The web application is based on client server architecture in which client can operate on its browser. Some of the examples of web applications are: webmail, online retail sales, online auctions, wikis, instant messaging services and many other functions.

1. Web user’s behavior is recognized first.
2. The Profiles of the customers are generated and according to the customer’s behaviour database is created. The database stores this information in the form of graphs and subgraphs.
3. Once graphs and subgraphs are generated, the proposed algorithm works and checks which user is browsing which information and also recommends this information to other users on the basis of their web behaviour. Either complete information called as graph isomorphism or part of the information called as subgraph isomorphism is recommended according to their needs.
The graph provides flexibility in solving real world problems and some features of graphs are balancing, modeling, and decision-making ability, providing brief idea, structural representation and relations among objects.

7.2 Objectives of the web user’s behaviour

1. To recommend the personal services based on the web behavior
2. To solve the problem of graph matching
3. To find out the availability of visited URLs and also finds where a substructure of interest is present within the whole structure
4. To improve the performance of the system
5. To significantly reduce the matching time

7.3 Architecture Design

Web user’s behavior is tracked based on usage history by generating graphs for every behavior. These graphs are stored in the database. Every time a new user’s behavior is found and subsequently the search pattern is also stored for the corresponding graph. After search pattern storage, user behavior is converted into a graph, that graph will be compared with the dataset of graphs which was generated for the different user’s behavior, using Subgraph isomorphism algorithm PSGIAlgo. This is the efficient technique for tracking a user’s behavior.

Architecture design of the application web behavior is shown in the figure 7.1. The architecture of the system is designed to show the behavior of the system and how the system works. Architecture can be designed for software as well as hardware. Software architecture defines the flow of the programme and the work assignment that must be carried out by the implementation teams.

The architecture is the essential transporter of framework characteristics, for example: execution, modifiability, and security, none of which can be accomplished without bringing together design vision. Engineering is a reality for early investigation to ensure that a plan approach will yield a worthy framework. By building successful architecture, one can distinguish configuration hazards and moderate them from the get-go in the advancement procedure. It can be applied to the design of other systems.
It speaks to an arrangement of deliberations that empower programming designers to portray architecture in unsurprising ways.

In the proposed application architecture, the designed system is used to recognise web user’s behavior by analyzing their search history. A Subgraph isomorphism algorithm is used to find out the similar search patterns of various users.

![Architecture Design of Web Application](image)

**Figure 7.1 Architecture Design of Web Application**

The process is given below:

- Firstly a new user is registered in the system
- The surfing history of registered user is stored in the database, history of links, URLs, etc.
- Further, these links and URLs are stored in the form of graph in the database
- The URLs are considered as vertex and links which are visited by users are considered as edges
- When a new user searches for a URL, graphs of different registered users are suggested by the application
- Then subgraph isomorphism algorithm recommends the matched URLs to the
7.4 Application Estimates

Cost of application can be found using any one of the model [120].

- COCOMO-1 Model
- COCOMO-2 Model

Model -1: The essential COCOMO model processes, programming improvement endeavors as a capacity of program measure communicated in evaluating lines of code.

Model-2: The middle COCOMO model registers programming improvement endeavors as an element of program estimate and an arrangement of cost drivers that incorporate subjective appraisal of the item, equipment, workforce, project qualities.

Model-3: The advanced COCOMO model fuses all qualities of the middle version with an appraisal of the cost drivers affect on each progression of the product designing procedure.

Following is the basic COCOMO -2 model.

The basic COCOMO -2 model equations take form:

\[ E = A(b) \times KLOC(b) \]
\[ D = C(b) \times ED(b) \]

Where \( E \) is the effort applied in person months. \( D \) is development time in chronological month. \( KLOC \) is estimated number of delivered lines of code.

The rough estimate of the number of lines of this is 9.072k. Applying the above formula

\[ E = 3.0 \times (9.072)^{1.22} \]
\[ = 44.20 \]
\[ D = 2.5 \times 44.35 \]
\[ = 9.40 \]

Hence, according COCOMO -2 model the time required for completion of this application is 9 (9.40) months.

Equation for calculation of cost of this application using COCOMO - 2 model is:

\[ C = D \times C_p \]
Where,
C = Cost of project
D = Duration in month
Cp= Cost incurred per person-month, Cp=Rs.5000/- (per person-month) (approx.)
C = 9 * 5000
= 45000/-
Hence, according COCOMO - 2 model the cost of this application is 45000/- (approx.)

7.5 Usage Scenario

This section gives a usage scenario to the product and further more depicts a genuine case of how at least one individual or associations interface with a framework.
Usage scenarios are connected with a few advancement forms, frequently in various ways. In subsidiaries of the Unified Process (UP) they utilize the assistance move from utilizing cases to sequence diagrams. The fundamental system is to distinguish a way through a use case, or through a segment of a use case, and afterwards compose the scenario as a case of that way.

7.5.1 User Profiles

The system creates a user profile when the first time a user logs on to a computer. At subsequent logons, the system loads the user’s profile, and then other system components configure the user’s environment according to the information in the profile.

7.5.2 Use Case View

Use case diagram is a graphical representation of a user’s interaction with the system and depicts the specifications of a use case [121].

A use case diagram can show the different types of users of a system and the various ways in which they can interact with the system. The use case diagrams are used to gather the requirements of a system, including internal and external influences.
The use case diagram of web behavior is shown in figure 7.2. This figure shows two users admin and system and they can interact with the cases: login, upload, result, find couple node, in-degree, out-degree, adjacent edges and logout. Out of these use cases, only a few of them are used by admin and others are used by the system. Admin only can interact with login, upload, result and logout. In this case, the admin has to login first to register in the system. Once user’s registration is done, he/she can upload the requested URL from the system or suggested by the system. Based on the similar patterns results are provided to users and then finally user can request for logout case. Similarly the system can interact with use cases: result, fond couple nodes, in-degree, out-degree and adjacent edges. After the registration of the user and user’s request, the system can determine the result based on its in-degree, out-degree and adjacent edges.

7.5.3 Functional Model and Description

A functional model, compared with the activity model or process model, is a graphical portrayal of an undertaking work inside a characterized scope. The reasons for selecting the functional model are to depict the capacities and procedures, help with disclosure of data needs, assistance distinguish openings, and build up a reason for deciding item and administration costs.
7.5.4 Data Flow Diagram (DFD)

A data flow diagram is a graphical representation of the “flow” of data through an information system, modelling its process aspects. Often they are a preliminary step to create an overview of the system which can later be elaborated. Data flow diagram can also be used for the visualization of data processing (structured design).

7.5.5 Data Flow Diagram: Level 0

Data flow level 0 diagram shown in the figure 7.3

![Figure 7.3 Data Flow Diagram Level 0](image)

7.5.6 Data Flow Diagram: Level 1

Data flow level 1 diagram shown in the figure 7.4

![Figure 7.4 Data Flow Diagram Level 1](image)

7.5.7 Activity Diagram

Activity Diagrams are graphical representations of the workflows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams are intended to model both
computational and organizational processes (workflows). Activity diagrams show the overall flow of control shown in the figure 7.5.

7.5.8 State Diagram

The state transition diagram is a transitional flow of states within the system. The states are represented in ovals and the state of the system gets changed when certain events occur. The transitions from one state to the other are represented by arrows.

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*Figure 7.5 Activity Diagram*
A component diagram displays the structural relationship of the components of a software system. These are mostly used when working with complex systems that have many components. Components communicate with each other using interfaces. The interfaces are linked using connectors.

7.5.9 Class Diagram

The class diagram is a static diagram. It represents the static view of an application. A class diagram is not only used for visualizing, describing and documenting different aspects of a system, but also for constructing executable code of the software application. The class diagram describes and operations of a class and also the constraints imposed on the system.