CHAPTER 4

PERSONALIZED ONTOLOGY BASED E-LEARNING SYSTEM WITH CLOSED SEQUENTIAL PATTERN MINING ON MULTIPLE DATABASES

4.1 INTRODUCTION

The key feature of this innovative work is to create personalized ontology by collecting information from the User Background Knowledge (UBK) and User Concept Knowledge Discovery (UCKD) for each learner. Suitable study material will be provided to the learner after mining the personalized ontology of the learner. The novel method contains various procedures such as the Creation of the Learner Profile, Personalized Ontology Generation, Ontology Mining through Inc Span\(^+\) algorithm, Concept extraction, Revision of skill level and Content Sharing. The appropriate study material has to be offered rooted on the skill level of the learners by means of the ontology creation procedure as the skill level changes for every learner. The skill level and the user’s interest on subjects is decided precisely by the creation of personalized instructor ontology engendered by the tutor.

4.2 PERSONALIZED E-LEARNING

The personalized E-learning represents an academic technique to furnish the project and challenge based together with the experimental learning. The personalization in the conventional learning content has to invariably meet the requirements of a large majority of the potential learners, whereas in the case of the E-learning content, it can be personalized in accordance with the specific requirements of the student concerned, who is always on the lookout for the learning content of his whims and fancies.
Endowed with the additional functionalities devised within the project, the ontology continues to be in the pivotal position as the link between the user requirements and the distinct attributes of the learning content. The Figure 4.1 shows the various approaches in Personalized E-Learning.

![Figure 4.1 Personalized E-learning approaches](image)

### 4.3 E-LEARNING TACTICS

The E-learning Performance is easily obtained by making use of several techniques such as the enhanced Instructional Design (ID), performance focus, E-Community, Greater integrity, Broader distribution, Performance Eco systems and the smart systems. The Figure 4.2 shows the E-learning tactics. The instructional design invariably contains the utilization of the immersive learning replications to locate the learners. The Advanced instructional design significantly scales down the course effectiveness, even though there are also other learning requisites. The practitioner has totally different performance requirements than the learner. As the learners become the practitioners, their motives undergo a sea change, their enthusiasm goes sky-high, and they invariably do away with the need for the whole packaging of a course.
Moreover, the E-Community characterizes the skill to co-operate regardless of time and/or distance, including the linguistic (text, voice) communication and visual/spatial illustrations. Further, the tactics authorizing the prior strategies go a long way in establishing fresh capacities. The underlying motive is focused on further tightening the incorporation of the twin functions of information creation and transmission.

![E-learning Tactics Diagram](image)

**Figure 4.2 E-learning tactics**

4.4 OBJECTIVES OF PERSONALIZED E-LEARNING

The main objectives of our Personalized E-learning System are shown below:

- To provide relevant study materials on the learners demanded area.
- To store an enormous amount of different types of learning materials.
- To design different user models.
To suggest the related learning style and delivery of useful learning materials from the storage space in a more considerable way.

4.5 PERSONALIZED ONTOLOGY BASED E-LEARNING SYSTEM ARCHITECTURE

The personalized E-learning represents a conceptualization model indicating and elucidating the user backdrop data by means of the personalized Instructor ontology model. In the innovative technique of personalized E-learning based on ontology creation, at the outset, a learner profile is generated and the knowledge level data is gathered regarding the learner about the stored local instance repository contents. The local instance repository includes the data collected from the user browsing history and the created profile details. So that, the user background knowledge can be obtained through the local instance repository with a view to finding the user requirement on study materials.

Moreover, the Concept Knowledge of the user is also discovered by means of world knowledge base (i.e., knowledge possessed by people and acquired through their experience and education), which could be retrieved by means of LCSH. Library of Congress Subject Headings (LCSH) contains a huge volume of library collections, facilitating to get the information about world knowledge base. In the personalized E-Learning, the function of learning is fulfilled by assessing the growth of ontology from the tutor. Thus personalized instructor ontology is developed with the help of the data gathered from both the User Background Knowledge and User Concept Knowledge Discovery unit.
The complete architecture of the Proposed Personalized E-learning is shown in Figure 4.3. In the stage of ontology mining, the IncSpan technique is elegantly employed for mining the closely related patterns from the created personalized instructor ontology. The ontology created in the innovative approach is by means of the Ontology Web Language (OWL). Then through the mined patterns, the relevant concepts were extracted. At the concept extraction stage, the relevant concepts were extracted.

![Figure 4.3 Personalized E-learning System Architecture](image)

**Figure 4.3 Personalized E-learning System Architecture**

Finally, the contents extracted were shared to the user, to gain knowledge on the topics. Subsequently, considering the Ontology, the tutor is competent to get a fair knowledge of the requirement of the learner on specific theory. At last, the tutor offers the contents in accordance with a requirement of the learner based on their background skill level.
4.6 PERSONALIZED ONTOLOGY BASED E-LEARNING SYSTEM ALGORITHM

This study proposes personalized E-learning system using ontology by creating personalized ontology user models. This model learns the knowledge level of the learners in the E-learning environment and strengthens the instructional design to make the content personalized. This innovative technique flows through the following phases during the course of execution.

- At the outset, a learner profile is generated and amassed in a local repository.
- Gathering data from Local Instance Repository (i.e., from user search history and user profile details) and world knowledge base through Library of Congress Subject Headings (LCSH).
- Concurrently, the instructor creates a Personalized Instructor Ontology by means of the knowledge attained from the User Background Knowledge and User Concept Knowledge Discovery, i.e., the knowledge attained from Local Instance Repository and World Knowledge Base.
- For every user, the personalized instructor ontology is mined with the help of the IncSpan$^+$ technique to extract the user relevant concepts in order to update their skill level from the Personalized E-learning environment.
- Extracting the relevant concepts and the contents will be once again revised before giving to the learners.
- Lastly, the content is furnished to the learner in accordance with the created ontology to update their knowledge about the particular domain.
The comprehensive step by step procedure of the innovative technique employing the personalized E-learning environment is effectively illustrated in the Figure 4.4.

<table>
<thead>
<tr>
<th>Steps</th>
<th>Process</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Initialization</td>
<td>Creation of Learner Profile Ontology</td>
</tr>
</tbody>
</table>
| Step 2 | Data gathering | Get data from  
» Local Instance Repository (LIR) from user detail and user search history → User Background Knowledge (UBK);  
» World Knowledge Base from Library of Congress Subject Headings (LCSH) → User Concept Knowledge (UCK); |
| Step 3 | Personalized Instructor Ontology generation | Generate ontology with the help of data gathered from User Background Knowledge and User Concept Knowledge by using the Ontology Learning Environment (OLE) tool |
| Step 4 | Ontology Mining | The closed sequential patterns were mined by means of IncSpan\(^*\) algorithm from the generated personalized instructor ontology generated. |
| Step 5 | Concept Extraction | Extracts the relevant concepts to be given to the learners for the user entering the system. |
| Step 6 | Revise | Revise the extracted contents. |
| Step 7 | Content Sharing | Share the topmost related contents to the users. |
| Step 8 | Update | Update the current knowledge level of the learner on the requested field. |
| Step 9 | Repeat | Repeat from steps 1 to 8 in case of new user entry |
| Step 10 | Terminate | Stop the process when the user needs to exit from the system. |

**Figure 4.4 Personalized E-learning algorithm**
4.7 IMPLEMENTATION OF PERSONALIZED ONTOLOGY BASED E-LEARNING SYSTEM

The success of a personalized system is to provide necessary optimum content to the learners. The proposed innovative teaching method uses a teaching and learning strategy by creating personalized ontology model for each learner. The personalized ontology allows an educator to rapidly adjust course contents and to make teaching learning activities more efficient and more closely tuned to students' needs. The innovative structure encompasses the following vital stages,

- Create Learner Profile
- Personalized Instructor Ontology Generation
- User Background Knowledge
- Concept Knowledge Discovery
- Ontology Mining
  - IncSpan^+ algorithm
- Concept Extraction
- Content Sharing and Skill Level Modernization

The Proposed Personalized Ontology E-learning Framework structure in detail is given in below steps.

4.7.1 Learner Profile Generation

The learner profile habitually contains the learner information, especially the personal details, performance records, security data, session particulars, target data and preference particulars. The Learner Profile Design is illustrated clearly in the Figure 4.5.
Figure 4.5 Learner profile design

4.7.2 Personalized Learner Ontology Generation

The personalized ontology will be created with the user background knowledge which employs the User Interest Catalog and User Personal Data for the building up of the ontology. Thus, the User Interest Catalog and User Personal Data effectively function as the user ontology backbone. The personalized ontology will be generated taking into account both the ontology backbone and the concept extraction module.

The personalized output will be achieved in the shape of the result by duly taking into consideration the ranking of contents and the Individual User’s Interest Classification. In this proposed work, for the purpose of creating the Personalized Instructor Ontology, the User Background Knowledge and the Concept knowledge has to be discovered in order to provide the study materials based on the learner interest on a particular domain and to fine tune their knowledge level. The mechanism of user personalized ontology generation and service is shown in Figure 4.6.
4.7.2.1 User background knowledge

The personalized ontology indicates the ontology which officially clarifies and specifies the user background data. For example, a user who searches for a word like varied anticipations for inquiring the matching query. In this scenario, the user may be suggesting the Under Graduate (UG) level or Post Graduate (PG) level or teaching on matching the subject. Here, the anticipation level is completely varied but the particular query is same. Therefore, it is necessary to provide the appropriate contents to the learners.

While the user may come from various backgrounds, then the user background data vary for each user. That the background data were collected from the acquiring user search history and their profile details. The user log details are collected by the admin through the Local Area Network (LAN) connection for getting the search history.
Depending on the user needs, and the suitable study materials supplied to them, the server system obtains the search history of the user by receiving access to their system. The CC Proxy software established at the server systems (i.e. admin) is used to recover the user details successfully. Hence, this proposed personalized E-learning system makes it possible for each user, the suitable contents in accordance with their user background data.

4.7.2.2 Concept knowledge discovery

The world knowledge base is discovered by the concept knowledge. The world knowledge base stands for the knowledge founded on experience. In our scenario of giving study materials, the Library of Congress Subject Headings (LCSH) will be exploited. The LCSH contains the library collection of subjects. The knowledge about the concept is founded by this LCSH; so that the related contents could be recovered depending on the user search history.

Alongside, the ontology with the help of the user concept knowledge and user background knowledge created by the instructor, the instructor produces the personalized instructor ontology likewise utilizing the ontology learning environment tool called as OWL. In the extended run, the produced ontology is refreshed, updated and accumulated for any updates in the Local Instance Repository (LIR) and the world knowledge base. Figure 4.7 shows the components in the Personalized Learner Ontology Generation System.
4.7.3 Ontology Mining

The study materials for every user on their interested area will be retrieved by mining the generated personalized user ontology. Here, the mining is made by means of retrieving based on the similarity matching between the content keywords. Also, the ontology mining will be made in such a manner to mine the closely frequent sequence patterns with the assistance of the Incremental Spanning algorithm.

4.7.3.1 Incremental sequential pattern mining

The Incremental Sequential Pattern Mining Algorithm (Incspan) constitutes a novel technique extensively employed for the incremental mining over the multiple database increments. However, it is not possible to achieve the entire set of repetitive sequential styles within the modernized data source by means of the IncSpan, thereby infringing the precision of the issue (Lei Chang et al. 2009).
4.7.3.2 Modified incremental sequential pattern mining

With an eye on overwhelming the deficiencies of the IncSpan, the modified incremental spanning (IncSpan+) is elegantly employed in the innovative module for mining the closed sequential patterns. The IncSpan+ algorithm stands ahead of the PrefixSpan and IncSpan upon incrementally modernizing databases by means of the gigantic setting.(Utpala Niranjan et al. 2011 and Liang Dong et al. 2014).

In this proposed work of mining the Personalized Instructor Ontology, there exist a number of database sources so that the learner can get their appropriate learning components. So in order to mine closed sequential patterns on multiple databases, the IncSpan+ algorithm is utilized in our proposed technique. The IncSpan+ ensures two vital tasks detailed as follows.

- The innovative discovery of the entire Frequent Sequential patterns (FS), which habitually guarantees the accuracy in the mining outcome.

- The innovative discovery of the whole Semi-Frequent Sequential patterns (SFS), which is fruitful with incrementally preserving the recurring patterns related to the extra database variations.

The Frequent Sequential patterns and Semi-Frequent Sequential patterns are generally mined independently just by means of any Sequential pattern mining techniques. With the intention of performing a single method, the IncSpan+ is employed to discover the FS along with SFS from the sequence database and the incremental database and also to achieve the total number of FS and SFS.
4.7.3.3 **INCSPAN**\(^+\) **algorithm**

The procedure of mining the sequential patterns is carried out with the help of the IncSpan\(^+\) technique. The incremental spanning method for the purpose of mining the sequential patterns for the multiple databases can be executed with the help of the steps explained below.

- The whole sets of FS and SFS are mined.
- For the multiple databases, the closed sequential patterns are created for the located frequent patterns.

Here, only the Frequent Sequential Patterns are selected and employed to create the appropriate closed sequential patterns for the input databases and the modernized databases. By performing the Modified IncSpan technique, the set of Closed Frequent sequential (CFS) patterns can be ascertained from the FS achieved from the sequence database and also from the incremental database.

4.7.3.4 **Closed frequent sequential pattern**

Let us consider two Frequent Sequential patterns ‘\(T\)’ and ‘\(R\)’, for which the Closed Frequent Sequential Pattern mining can be illustrated by the Equation (4.1).

\[
S_{CF} = \{ T \mid T \in S_F \text{ and } R \in S_F \text{ such that } T \subseteq R \text{ and } \sup(T) = \sup(R) \} \tag{4.1}
\]

- \(S_{CF}\) - Closed Frequent Sequential Pattern
- \(S_F\) - Frequent Sequential Pattern
- \(\subseteq\) - Subset; \(T \subseteq R\) - pattern ‘\(T\)’ is a subset of ‘\(R\)’
- \(\sup(T)\) - support value of ‘\(T\)’
- \(\sup(R)\) - support value of ‘\(R\)’
The closed sequential patterns are established to be more effective when compared with the parallel patterns as it efficiently limits the generation of the number of sequential patterns. Every sequential net access pattern in the pattern collection $S_F(i)$ is at first harmonized with certain another pattern in the collection, i.e., $S_F(j)$. If both the conditions shown below are fulfilled then a pattern $S_F(i)$ is essentially achieved from the pattern collection $S_F$.

- Both the patterns $S_F(i)$ and $S_F(j)$ continue to possess the similar support.
- $S_F(i)$ represents predominantly a subset associated with $S_F(j)$ and it is represented by the Equation (4.2).

$$S_F(i) \subseteq S_F(j)$$

(4.2)

In the long run, the closed pattern collection $S_{CF}(S_{CF} \subseteq S_F)$ is essentially generated from the pattern collection $S_F$.

4.7.4 Concept Extraction

The concept extraction process is performed with the information attained by means of the Experts Recommendation, User Feedback, User Search Keywords, User Search History and the User’s Browsing Catalog. In respect of the user who is getting admitted to the personalized teaching and learning system, the concepts are extracted from the generated personalized instructor ontology based on their knowledge levels. As the personalized teaching and learning system is already educated with the user interest with the help of the personalized instructor ontology creation, it is extremely convenient to get the topic of preference of users and thus extracting the suitable concepts by mining the ontology.
4.7.5 Content Sharing and Skill Level Modernization

The attained concepts are thereafter again revised with the extracted concepts to have fruitful data and to ascertain the subject on which the user is interested to get any knowledge. The User Personalized Instructor Ontology rooted on the User Preference is created for each and every user and the learner is offered the ranked contents after carrying out the Individual User’s Interest Classification on the relative subject (i.e., modernizing the extracted concepts and offering it to the learners). In accordance with this, the skill level is appraised and modernized for each and every student getting admitted to the personalized instructor ontology system. The contents are to be furnished frequently after every requested topic, in order that the learner is competent to attain knowledge regarding the requested topic. In this manner, the learner gets educated and the skill level is revised on the needed domain topics.

4.8 PERSONALIZED ONTOLOGY BASED ADAPTIVE E-LEARNING FRAMEWORKS

Adaptive systems dynamically revise and deliver instructional materials according to the learners’ current progress but Personalized systems provide personalized content based on the characteristics of the learners. Combining the features of both Personalization and Adaption in a single framework, this work proposes a framework. This framework consists of personalized learner ontologies which provide a conceptual knowledge structure of user in the particular domain and allow the instructor to rapidly adjust course contents and to make teaching learning activities more efficient and more closely tuned to students' needs. This framework also provides appropriate adaptive content automatically to the learners at the right time by determining the knowledge level for the efficient learning outcome.
<table>
<thead>
<tr>
<th>Steps</th>
<th>Process</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creation of Learner Profile Ontology</td>
<td>Learners Register with preferred topics and user details and Creation of Learner Profile Ontology (LPO)</td>
</tr>
<tr>
<td>2</td>
<td>Data gathering for enhancing ontology</td>
<td>Get data from » Local Instance Repository (LIR) of user detail and user search history to get <strong>User Background Knowledge</strong>; &amp; » World Knowledge Base from Library of Congress Subject Headings (LCSH) to get <strong>User Concept Knowledge</strong>;</td>
</tr>
<tr>
<td>3</td>
<td>Personalized Instructor Ontology generation</td>
<td><strong>Generate ontology</strong> with the help of data gathered from User Background Knowledge and User Concept Knowledge using Ontology Learning Environment (OLE) tool</td>
</tr>
<tr>
<td>4</td>
<td>Ontology Mining</td>
<td>The <strong>closed sequential patterns</strong> were mined by means of <strong>IncSpan</strong> algorithm from the generated personalized instructor ontology generated.</td>
</tr>
<tr>
<td>5</td>
<td>Provision of Personalized Contents</td>
<td>Provide personalized contents to the learners.</td>
</tr>
<tr>
<td>6</td>
<td>Online Examination</td>
<td>Make tests on that contents</td>
</tr>
<tr>
<td>7</td>
<td>Text Pre-Processing</td>
<td>Perform Text Pre-Processing for the obtained answers. The steps are • Document parsing • Stop word removal • POS tagging • Stemming • Filter specific linguistic patterns.</td>
</tr>
<tr>
<td>8</td>
<td>Text Matching and Dimensionality Reduction</td>
<td>Text Matching is made with word net for the pre-processed text document and original test document. <strong>Singular Value Decomposition (SVD)</strong> is to reduce the dimensionality of the text matched matrix.</td>
</tr>
<tr>
<td>9</td>
<td>Neuro Fuzzy Logic</td>
<td>Employing Neuro Fuzzy Logic to the text matched matrix to get score values <strong>Get Contents</strong> for score value outcome less than particular thresholds otherwise <strong>Re-Examining</strong> <strong>Repeat</strong> Step 1 to 9 <strong>Until</strong> the Learner is fully Updated.</td>
</tr>
<tr>
<td>10</td>
<td>Concept Extraction</td>
<td>Extract the concepts on which the learner is fully skilled.</td>
</tr>
<tr>
<td>11</td>
<td>Concept Map Generation</td>
<td>The extracted concepts were drawn in the form of a concept map for the ease of instructor to view the current status of learner.</td>
</tr>
</tbody>
</table>

**Figure 4.8** Personalized ontology based adaptive e-learning framework
The Figure 4.8 shows the Personalized Adaptive Ontology based E-learning Framework. The objective of this framework is to make teaching learning more effective and it provides the learner both personalized and adaptive learning content. This will reduce the learner learning time and it provides more personalized learning path to the learners. This framework enhances the teaching and learning process by combining both personalization and adaptiveness in a single framework and in same environment.

4.9 CONCLUSION

The personalized E-learning represents a conceptualization model indicating and elucidating the user backdrop data by means of the personalized Instructor ontology model. In the innovative technique of personalized E-learning based on ontology creation, at the outset a learner profile is generated and the knowledge level data is gathered regarding the learner about the stored local instance repository contents. The Local Instance Repository (LIR) includes the data collected from the user browsing history and the created profile details. So that, the User Background Knowledge (UBK) can be obtained through the LIR with a view to find the user requirement on study materials.

Moreover, the Concept Knowledge of the user is also discovered by means of world knowledge base (i.e., knowledge possessed by people and acquired through their experience and education), which could be retrieved by means of LCSH. Library of Congress Subject Headings (LCSH) contains a huge volume of library collections, facilitating to get the information about world knowledge base. In the personalized E-Learning, the function of learning is fulfilled by assessing the growth of ontology from the tutor. Thus personalized instructor ontology is developed with the help of the data gathered from both the User Background Knowledge (UBK) and User
Concept Knowledge Discovery (UCKD) unit. The appropriate study material has to be offered rooted on the skill level of the learners by means of the ontology creation procedure as the skill level changes for every learner. The skill level and the user’s interest on subjects is decided precisely by the creation of personalized instructor ontology engendered by the tutor. In this chapter, the new Personalized Adaptive learning system framework has been proposed to enjoy the facility of both Personalization and Adaptation in a single structure. The test bed used to evaluate the framework and the results obtained are discussed in the next chapter.