Artificial Intelligence Techniques in Software Engineering for Automated Software Reuse and Design

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Abstract—**Mining of software engineering data have proved successful for reusability of components in software development. Artificial Intelligence improves a large application domain of software engineering activities. Intelligent knowledge discovery integrates Artificial Intelligence with Data Mining for intelligent computing of software engineering tasks. The integration of artificial intelligence with data mining for supporting software engineering applications leads to Software Intelligence. This paper analyzes three artificial intelligence techniques that uses data mining, business intelligence, machine learning for promoting automated software reuse for software construction and overall software development. The business intelligence tools are used for intelligent knowledge discovery of code that will be used for reusability of applications and components. An analysis of several AI techniques in software reuse domain of software engineering is discussed for automated software reuse and identification of potential research prospects in the field.**

Keywords—Software Reuse, Artificial Intelligence (AI), Business Intelligence (BI), Software Intelligence (SI).

I. INTRODUCTION

Software engineering tasks involves various activities that cut across all the stages of the Software Development Lifecycle (SDLC) phases. Various data mining techniques have been applied for extracting useful knowledge from data obtained throughout the process of SDLC. This paper discusses about various artificial intelligence techniques that have applications in automation of software design with reusability. Artificial intelligence techniques like artificial neural networks, fuzzy logic, intelligent knowledge based systems, data mining etc. have been exploring the software engineering field for solving several software engineering problems. But the risks associated with the increasing software complexity needs automation of all the above techniques. As the software grows in size the complexity increases with increase in time and cost for the overall software construction. There is a huge amount of data generation from all the stages of SDLC. The data varies from requirements analysis and specification, system and software design, implementation and unit testing, integration and system testing, operation and maintenance phases [4]. the data generated at the system and software design phase takes the whole software architecture and design patterns for reuse. Mining of these huge data proves successful for knowledge discovery and identification for component for productive reuse. However integration of AI in the process improves the overall process of software development with reusability and supports automation for organizational standards. This paper aims at presenting various facets of AI in software reuse domain of software engineering for promoting software intelligence. The analysis of most

significant AI techniques that are relevant in the software reuse domain and the whole sphere of the software engineering field are tabulated in the last section. Feldt et al., have presented the AI in SE Application Levels (AI-SEAL) taxonomy that categorizes applications according to their point of AI application, the type of AI technology used and the automation level allowed [1]. This proves that AI in software engineering domain is a very promising research area and exploring in depth is of relevance in solving various software engineering related problems and concerns. Innovative applications of artificial intelligence techniques in software engineering like schedules for software development projects as well as Information Technology management, software application development and software security have been considered [3]. Raza Et al., have discussed about the AI techniques in software development along with risk management phase in AI based systems and genetic codes [6]. Thus knowledge discovery with AI is significant in automated software reuse and design in the software engineering field.

The paper is organized into five sections. Section I deals with introduction part and discussed about significance of AI in the sphere of software engineering . Section II deals with the significance of AI in software engineering with data mining where knowledge based systems and business intelligence will be discussed along with their present importance in the overall software development. Section III discusses about the automated software construction with software intelligence for reuse in systematic software development. Section IV addresses the various AI techniques for software reusability where an analysis of AI techniques in reusability is discussed with a tabular approach and in accordance with the present research relevance.The last section concludes the paper along with reference that support and are relevant to the topic of the research field.

II. AI IN SOFTWARE ENGINEERING WITH DATA MINING

Mining of software engineering data has been a successful domain for extracting useful information from various types of software repositories for resolving potential software engineering problems. There are several applications of artificial intelligence that employ data mining in software engineering domain. But employing business intelligence with software development remains a potential search area for automation of software intelligence tasks. Various business intelligence tools are already available in the market that support the software development activities in organizations. The role of AI in software engineering has

been emphasized by Harman et al., with search based software engineering and work on probabilistic reasoning and machine learning in the field [7]. This section discusses about the role of AI in software engineering field along with the amalgamation of three most prominent research fields of software engineering, data mining and artificial intelligence to support the concept of software intelligence and thus leading to automation of the whole software development process.

A. Knowledge Based Systems with Mining of Software Engineering Data

Knowledge discovery in software repositories has been very promising and successful research field for solving various software engineering problems. Mining of software engineering data and the related software metrics like Software metrics such as Cyclomatic Complexity, Cyclomatic Density, LOC Total , LOC Executable, LOC Comments, LOC Code and Comments, LOC Blank, Number of Lines, Node Count , Edge Count, Weighted Methods per Class, Depth of Inheritance Tree, NOC Number of Children, Coupling between Object Classes, Response for a Class, Lack of Cohesion of Methods, Method Hiding Factor, Method Inheritance Factor, Polymorphism Factor, Coupling Factor, Number of interfaces, Class size, Number of classes, etc. have been classified for easy application of data mining techniques in software reuse process [15]. Knowledge based systems are a fruitful source for amalgamation of artificial intelligence with software engineering for reusability of potential components. Business Intelligence is analogous to software intelligence as both the platforms aims at integrating artificial intelligence pertaining to successful decision making in businesses and software's respectively.

B. Business Intelligence for Software Engineering

The future trend of artificial intelligence with software engineering deals with modeling of objects of real world like business process, expert knowledge or process models and research areas like agent oriented software engineering, knowledge based systems, computational intelligence and automated software engineering find importance in both the research fields[8]. Business intelligence integrates the process the integrating intelligence in the software engineering tasks which will lead to automation of software development process. The following Fig.1 gives a roadmap to software intelligence with intelligent knowledge discovery from software engineering data. This will lead to intelligent automation of of the software industry.

Knowledge discovery process -----> Artificial Intelligence-----> Software Fngineering ------> Software Intelligence-----> Intelligent Software Reuse ----> Intelligent Software libraries -----> Intelligent automation

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Fig. 1. Roadmap to software intelligence with intelligent knowledge discovery from software engineering data

This roadmap is the future to various automation tasks in the software engineering field employing data mining and artificial intelligence.

III. AUTOMATED SOFTWARE CONSTRUCTION WITH SOFTWARE INTELLIGENCE FOR REUSE

Software construction involves the whole arena of the Software Development Lifecycle (SDLC) with huge data being processed at all the stages. The increasing software complexity makes the data processing slow with such a large amount of data being generated at all the SDLC levels. Mining of useful information at all the stages of SDLC makes the knowledge discovery process fruitful for use in the reusability of potential components. Software reuse makes the task of application development easy and time preserving. The components that are the potential candidates for reuse in the applications development are carefully selected and should be employed with high quality components that are bug free and adapted to changes in the current trend and technologies. For effective and efficient reusability the reusable components should be developed with a problem- driven methodology and problem solving approach of various software engineering tasks. There is a need for employing intelligence in the above process of software reusability so that the process of software construction becomes automated and the reusable components are selected keeping in view the problem domain of the software engineering task. Furthermore it will help in maintaining the software quality, will make the software more efficient and easily adaptable to changes in technology and thus reduce the cost and time for the overall software development.

A. Systematic Software Development with AI

Automated software construction involves integration of artificial intelligence techniques with software engineering and data mining. Mining of software engineering data will help in extracting useful knowledge for identification and selection of potential candidates for reuse and the consolidation of artificial intelligence techniques will aid in employing intelligence to the above stated process. This will lead to automation of the whole sphere of software engineering activities involving software reuse. Software Intelligence is known with Business Intelligence in organizations as BI supports SI in software business. The whole The area of software intelligence can be explored for reusing traditional BI platforms for adoption of BI infrastructures in large organizations [2]. Systematic software development can be enhanced with the integration of artificial intelligence techniques at all the levels of software development. The architecture, process and organization of software reuse is significant for business success with reuse business framework in reuse driven software engineering [11][12]. The amalgamation of three most promising and significant fields of software engineering, data mining and artificial intelligence will help in the promotion of software intelligence and thus will ultimately automate the process of software construction with reusability as a special byproduct of the above process. That is software intelligence which is employed with AI and mining tasks supports the whole platform of software

development with all the stages of SDLC in dynamic state and software reusability as a particular yield for future software developments at organizational level. The next section discusses about the various AI techniques that have a significant role in the domain of software reusability for systematic software development.

IV. ANALYSIS OF ARTIFICIAL TECHNIQUES FOR REUSABILITY

Artificial intelligence techniques such as knowledge based systems, neural networks, fuzzy logic, machine learning and data mining have been explored as the way to improve many of the software development activities [9]. Amaar at al., have discussed about application of AI in requirement engineering, software architecture design, software coding and testing and automation of programming process [10]. This section provides a tabular analysis of three Artificial Intelligence techniques that are prevalent in the software reuse domain of software engineering. Only the prominent techniques are stated in a systematic broad area. Various other AI techniques are present that aid in the software development process. This paper discusses the three AI techniques like data mining, machine learning, neural networks which are detailed in separate tabular form for showing their individual relevance in the broad area of software engineering with software reuse as a significant field of software engineering. The most significant techniques are mentioned in the table and have relevance in the whole sphere of the software engineering field with software reuse as a special domain for promotion of software intelligence in organizations.

Table I below states the various data mining techniques that are used in the mining of software engineering data for software reuse. Mining techniques like classification, clustering, associations, regression, summarization and generalization, dependency modeling, change and deviation detection, model visualization and exploratory data analysis etc. have been stated in the table below [4]. Mining algorithms like association rule mining, frequent subgraph mining, partial order mining, graph matching, clustering, classification etc. have been used for several software engineering tasks like debugging, maintenance, bug detection etc. Software developers are in need for Software Intelligence (SI) which is like Business Intelligence (BI) uses fact based support system to improve business decision making by using fact-based support systems to support their daily decision-making processes [2]. The table below lists down the frequently used data mining techniques in the software development process that supports software reuse domain of software engineering.

TABLE I.   ARTIFICIAL INTELLIGENCE TECHNIQUES FOR SOFTWARE ENGINEERING: DATA MINING

AI Techniques	Artificial Intelligence in Software Engineering		
	Data Mining in Software Engineering	*Software Engineering Area*	*Applications*
1.	Knowledge discovery	Software Reuse	Software reusability activities
2.	Classification	Software Reuse	Identifying software components
3.	Clustering	Software Reuse	Predicting reusability
4.	Hierarchical clustering	Software Modeling	Software Design and patterns
5.	K-NN and neural networks	Software Evaluation	Evaluating software activities
6.	Neural network and classification	Software Reuse	Identifying software component
7.	Classification, Decision Trees and Clustering	Software Reuse	Classification and retrieval

Table II below states the various machine learning techniques that are used in the software engineering platform. The deep learning methods held software developers to extract requirements from natural language text , generate source code, predict defects in software etc. and for various other software engineering tasks [13]. Machine learning techniques like deep learning, deep believe networks, similarity computing, generalize program abstractions, clustering of components etc. are used in the software reuse domain of software engineering [14].

TABLE II.   ARTIFICIAL INTELLIGENCE TECHNIQUES FOR SOFTWARE ENGINEERING: MACHINE LEARNING

AI Techniques	Artificial Intelligence in Software Engineering		
	Machine Learning in Software Engineering	*Software Engineering Area*	*Applications*
1.	Deep Learning model- Auto Encoder (AE)	Software engineering tasks	Software Reusability and other software engineering tasks
2.	Deep Learning model- Auto Encoder (AE)-Deep belief networks (DBN)	Software engineering tasks	Software Reusability and other software
3.	Deep Learning model- Convolutional neural network (CNN)	Software engineering tasks	Software Reusability and other software
4.	Deep Learning model- Recurrent neural network (RNN)	Software engineering tasks	Software Reusability and other software
5.	Instance based learning/ Case based reasoning (IBL/CBR)	Similarity computing	Software Reusability
6.	Explanation based learning (EBL)	Generalize program abstractions	Software Reusability
7.	Instance based learning/ Case based reasoning (IBL/CBR)	Locate and adopt software to specifications	Software Reusability
8.	Decision tree learning (DT)	Cost of rework	Software Reusability
9.	Instance based learning/ Case based reasoning (IBL/CBR)	Active browsing	Software Reusability
10.	Genetic Algorithms (GA)	Clustering of components	Software Reusability
11.	Instance based learning/ Case based reasoning (IBL/CBR	Knowledge representation	Software Reusability

Table III below states the various neural network techniques like artificial neural networks, multilayer perceptron, neuro fuzzy etc. that are used in the software engineering platform. Neural networks have been used for identifying and searching of reusable components. Component Based Software which help in achieving software quality along with efficiency are based on parallel processing and neural networks are considered for enhancing the same [5].

TABLE III. ARTIFICIAL INTELLIGENCE TECHNIQUES FOR SOFTWARE ENGINEERING: NEURAL NETWORKS

AI Techniques	Artificial Intelligence in Software Engineering		
	Neural networks in Software Engineering	*Software Engineering Area*	*Applications*
1.	Artificial Neural Networks	Software Testing effort estimation	COCOMO, defect removal etc.
2.	Neural Network model - Multilayer perceptron	Software development effort estimation	COCOMO, FP, LOC etc.
3.	Neural Networks	Software cost estimation	UFP, LOC, COCOMO etc.
4.	Artificial Neural Networks	Reusability assessment	Software reuse
5.	Feed forward neural network, recurrent neural network	Software Reliability	Software reliability growth models
6.	Neuro-fuzzy and neural networks	Software Reliability	Reliability models
7.	Neural networks, fuzzy systems	Component based software engineering	Software reusability
8.	Evolutionary algorithms	Component based software engineering	Software reusability

V. CONCLUSION

This paper presents the analysis of various artificial intelligence techniques for software reuse domain of software engineering. The integration of artificial intelligence with data mining for supporting software engineering applications leading to Software Intelligence for promoting automated software reuse for software construction and overall software development. An analysis of several AI techniques discussed will lead to prospective identification of potential research prospects in the field of artificial intelligence with software reuse domain of software engineering.

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