

A Social Creativity Support Tool Enhanced by Recommendation Algorithms: The Case of Software Architecture Design

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Abstract Reusability of existing knowledge for the design and development of new ideas is a key principle of the definition of creativity as a process. Professionals to create the Architecture design of innovative software tools use software Architecture Design as such process. This work proposes a framework/tool by which the design of SAD can be directed based on several types of recommendations and in particular of well-known design patterns [1]. This work approaches the recommendations the use of contextual factors in combination with recommendation methods and known recommendation algorithms.

1 Introduction

A creativity outcome is a sequence of thoughts and actions that lead to a novel adaptive production [5]. Plucker and Beghetto [8] define creativity as the interplay between ability and process by which an individual or a group produces an outcome or product that is both novel and useful as defined within some social context. Having assumed that creativity is an attribute that we all have, we reach the conclusion that it is necessary to find ways and means to assist in outsourcing this property. Creativity is a characteristic that can be cultivated and at the level of its development is different for each person. Cultivating and expressing the creative

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ability can be achieved through help and guidance. One approach to achieve that is through the use of Creativity Support Tools (CSTs). Creativity Support Tools are software systems that can emulate a realistic creative process by offering the users the ability to record thoughts and ideas with the use of ICT means. The utilization of the existing CSTs is bounded to the replacement of the conventional means of collecting ideas, such as the paper or the white board, with corresponding virtual environments, but they also offer the users the possibility to collaborate with other people from a distance.

This research aims to reinforce the importance of these tools with the addition of more advanced functionality. Generally, CSTs are the basis for strengthening the creative capacity and they can also be used for the cultivation of the creative ability. At this stage, these tools lack the mechanisms that can create the necessary stimulus to the user, which would make the user more productive in the process of creativity [10]. Such mechanisms are the recommendation systems for the support of the creativity process like for example the recommendations of people to collaborate with, related problems or solutions, related ideas and finally related resources such as articles, images or videos. Recommendation systems are systems that belong to the information filtering systems family. In general Recommendation systems seek to predict the rating or the preference that a user would give to an item. Thus the common methodology that the recommendation systems follow is to find the correlation between three types of modeling, user, rating and item modeling in order to produce recommendations. The use of recommendation systems to support a creativity process is a challenging task due to the multi-dimensionality of factors that influence the process and the complexity in identifying the type of recommendation that can foster creativity at each phase of the creativity process within a Creativity Support Tool.

The motivation for this work is driven from the notion that Creativity and Innovation are keys to success for any business. The development of a Social Creativity Support Tool (SCST) can become the means of bringing professionals and experts together for the exchange of ideas and collaborate together through creativity support spaces supported by user aiding functionality.

For example at the existing CSTs noticed that they lack of methods for finding people while formulating a collaboration team. The functionality they support regarding the group composition for collaboration is only the invitation of person to join a creativity session without analyzing her knowledge background and the level of competence related to the project. The use of a social network designed for creativity will give the opportunity to a practitioner to get recommendations of experts in a particular topic who are (or not) in the same company or organization and can add value to a creative project that is processed. A social creativity network can be beneficial for businesses in two ways. On the one hand it will be used as means for collaborations between companies (public social web network). On the other hand it will be used as a tool that connects employees of large scale international companies (intranet application). The supporting recommendations can vary according to the context of the creative project and the type of actions needed

for the successful completion of a creative project. In that case the interfaces, the tools and the supporting functionality can be different based on the context of the project.

2 Problem Statement

In this research it is stated that social creativity tools integrated with context aware recommender systems can positively influence the creativity process. Context aware recommendations such as recommendations of users for collaboration or resources related to the context of a creative project but also other recommendations related to particular creativity phases can facilitate the creativity process. Therefore the problem approached has two parts: first the development of a Social Creativity Support Tool for the development of professional networks targeted in solving problems and producing innovative ideas and second the development of a context aware recommendation algorithm, which will have the flexibility to analyze the most important contextual factors for each phase of the creativity process and produce useful recommendations to foster the professionals' creative ability.

3 Approach

As mentioned above, the creativity process is not a straight-forward process. On the contrary, it is characterized by dimensions that may vary depending on the domain it is applied to. According to the problem statement, the expected outcomes of this work are related to creativity as the main research area. The wideness of the creativity topic though makes the design of a research plan very complex. For example a creativity process may be an art session, a book conversation or the development of a web site. So to study the research hypothesis a particular topic was selected in order to model creativity and to extract valid conclusions. Therefore we framed the problem into a particular creativity-related problem, that of the Software Architecture Design (SAD) process. SAD is by default a creativity process since it is a process that is executed in phases by individuals or groups of experts. The participants of such a process must have an important knowledge background in the topic and be able to exchange expert opinions/ideas for each phase of the SAD lifecycle process. For the study of SAD as a creativity process and following the problem statement, a Creativity Support Tool has been developed for the support of SAD. The SCST will be the tool on which the users will be able to create professional networks for collaborative creativity sessions. The development of the creativity tool and the integration with the proposed recommendation algorithms will be used as prototype for the examination of the current work's research questions. In particular, the research goals that were set for the current research work are listed in the rest of this section.

3.1 *Research Goals and Methods*

To assess the impact that Context Aware Recommendations have in creativity process within a Social Creativity network, the following set of objectives have been determined:

- Define the creativity context elements and design of a creativity model that will be applied in a social creativity network.
- Define the process of SAD through the designed creativity tool and identify the types of recommendations that must be applied at each step.
- Define the recommendation algorithms and in particular specific recommendation methods for recommending SAD oriented types of recommendations such as, recommendation of Design Patterns, for the examination of how such recommendations are influencing the SAD as a creative process.
- Design the evaluation plan to lead to evaluation results concerning:
 - The usability of the SCST
 - The accuracy and validity of the proposed recommendations
 - User satisfaction and experience by using types of recommendations such as recommendation of users to collaborate, resources and most importantly the recommendation of Design Patterns in order to facilitate users in designing Software Architecture independently to the knowledge level they currently have.
 - Impact of Context Aware Recommendations in creative ability of the users

The outcomes of this research are expected to be taken by applying the prototype in a large scale international IT company whose employees will be asked to create profiles in the prototype application. Then a group of Software Architect Analysts will be asked to design new projects with it. They will be asked to formulate groups of users to collaborate with, from branches of the company that are in other countries and use the recommender system to collect resources related to a given project. With the design of a prototype for a domain specific group of users will lead to the collection of results regarding the creativity impact as well as the overall users' satisfaction and the prototype usefulness. The results of the test will be used for further improvements of the prototype the improvement of the proposed recommendation algorithm and also lead to the design of new methods and variations of the recommendation algorithms that will be applied.

4 **SAD Recommendations—Related Work**

The last years Design Patterns for Software Architecture design are increasing. New patterns are appearing and applied widely. Gueheneuc and Rabih [4] proposed a methodology of recommending design patterns through the textual analysis of each

pattern into the most important words and computing the similarity distance between those words and the words of the query given by the user. Gomes et al. [3] proposed a Case Based Reasoning Recommendation system for the recommendation of Design Patterns based on previous experiences using a Design Patterns Knowledge Base and related taxonomies. A similar system developed by [11] that recommends patterns using the Implicit Culture Framework (ICF). The recommendations are produced based on the users previous actions, based on conventional Information Retrieval and CBR methods. Palma et al. in [6] propose a DPR framework which recommends patterns based on predefined questions that the designers have to answer, and based on the given answer the framework has a weighting mechanism for the selection of the appropriate pattern. The initial identification of patterns that can be used through the DPR framework [6] are selected through LUCENE indexing and TF-IDF filtering of the query given and the intent description of each pattern.

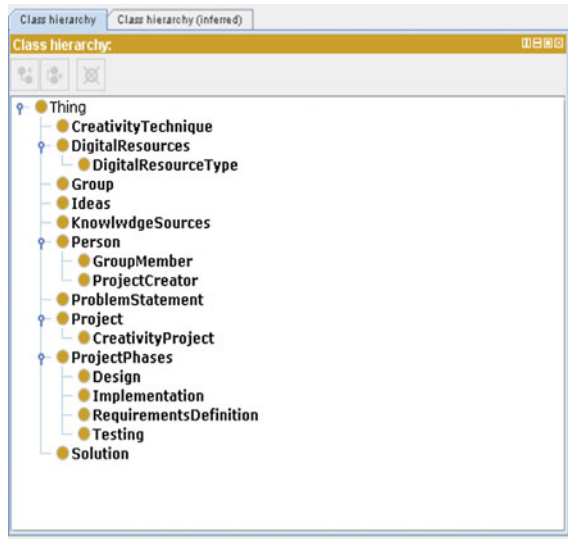
5 Current Status

The research work described through the objectives definition in Sect. 3 is a work which is still in progress. Most of the objectives are currently met in the current status of the work, but some are still in progress. In particular, at the time being we defined the contextual model of creativity which is designed and represented in the form of ontology. The Contextual model is an extension of the proposed ontology proposed in previous work of ours in [9]. The new ontology is taking into account additional conceptual elements related to the phases of the creative process as a SAD process. With the use of the designed ontology it became possible to bring data from different data sources such as existing software design repositories like [GitHub.com](https://github.com) and [Sourceforge.net](https://sourceforge.net) and combine them with the new data that is created in the local database of the SCST. Based on this model we managed to define the most important relations that can be used as input data for the recommendation algorithms that we use.

Having the Creativity Contextual Model defined in the form of ontology, and taking into account the semantic data and relations of the model, we developed a Knowledge Base tool by which a user is able to browse through the existing SAD projects, the participants of the projects and the metadata related to each particular entity (Fig. 1).

As shown in Fig. 1 the ontology contains the concepts of a creativity project and the project phases that a project may have during its execution. Based on these concepts/classes several triples are defined such as for example (*Project*, *projectCreatedBy*, *projectCreator*), (*ProjectGroupMember*, *isMemberOf*, *ProjectGroup*), etc. Using the triples defined in the ontology and with the use of SPARQL queries it is feasible to collect data from several domain specific data sources and create an interactive Knowledge Base. The importance of ontology is not only tracked to the concentration of data from other sources into one

Fig. 1 Creativity ontology model



Knowledge Base, but also into the formalization of data into a structured form. By structuring the data following the defined concepts and their relations facilitates the filtering of data to be used in the computation of recommendations related to the design and development of new Software Architecture Design projects. The proposed creativity model consists of a structural representation of the ingredients of a project (abstract form, not particularly for SAD) such as the type of project, the Participants of project Groups; the Phases of executing a Project or the Creativity Techniques that are used for the execution of a Project.

In terms of the general concept of using recommendations for the enhancement of creativity we suggest types of recommendations like recommendation of relevant projects while a new project is created, recommendation of related resources, recommendation of peers to collaborate with and recommendation of Design Patterns to facilitate the Architecture Design process. The main objective of this work is the context aware recommendations of Design Patterns and the influence of the recommendations in the creative outcome of the process.

The knowledge Base tool is part of the overall SCST which in its whole contains a second sub-tool which is used for the design of Software Architecture Diagrams. The flow that can be followed by end users in order to open an existing Design project or create a new one defines the proposed workflow process for the SAD as creative process. Thus at each phase of the process we defined specific Context Aware Recommendation types that vary based on the process phase and the available context information. In addition to that, social networking functionality is also added in particular phases such as professional network connections between designers; *Follow* a professional's activities or view the progression of selected SAD projects, which are in progress by other professionals.

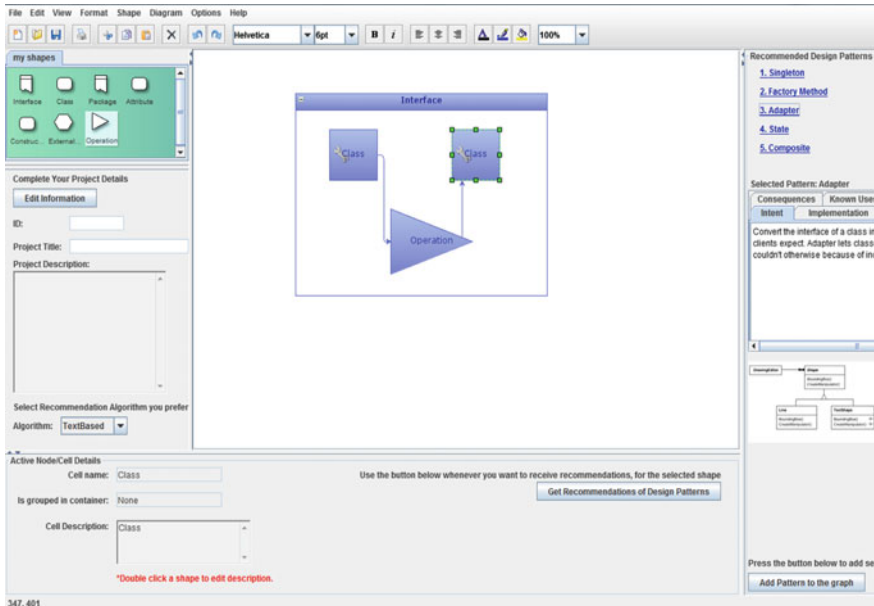


Fig. 2 Software architecture design editor enhanced by context aware recommendations of design patterns

A lot of effort at the current state of the research is given in producing recommendations on Design Patterns during the SAD in the form of diagrammatic design (Fig. 2).

The recommendation of Design Patterns consists one of the most important tasks of this work and to meet that objective we developed a mechanism by which, we use three different recommendation methodologies. The methodologies used are the following: 1. *Lucene indexing, TF-IDF [7] and Cosine Similarity*, 2. *Graph based recommendations using Design Patterns rules* and 3. *Recommendation of Design Patterns Based Context Elements and Utility Function*.

Lucene indexing: Assuming that during the definition of a new SAD project the designer defines a list of metadata information for the project and during the design of the diagram, designer is able to define metadata for each particular node of the diagram, we can construct queries, which can be used to filter patterns using text comparisons. The text comparisons can be made between the selected metadata (considered as context elements) and the attributes of each pattern. The patterns attributes are indexed with the use of Lucene Framework and the text a comparison between metadata and pattern attributes is done with the use of the TF-IDF [7] algorithm and the cosine similarity for the computation of the similarity distance between the matching pattern attributes.

Table 1 Sample of patterns list and the decision rules for each pattern used in method 2

Pattern name	Pattern category	Definition	Design purpose
Factory	Creational	Number of classes linked to a constructor element	Create individual objects in situations where constructor is inadequate
Singleton	Creational	If the class does not belong to a container or is member of a container which contains two and more containers	Ensure that there is exactly one instance of a class S. Be able to obtain the instance from anywhere in the application
Facade	Structural	Set of classes in package Packages all together in one interface	Provide an interface to a package of classes
Adapter	Structural	If existing functionality—external element is used	Allow an Application to use external functionality in a retargetable manner
Interpreter	Behavioral	If notes elements are linked to the classes	Interpret expressions written in a formal grammar
Iterator	Behavioral	If operation node exists between to classes	Provide a way to access the elements of an aggregate object sequentially without exposing the underlying representation

Graph based recommendations using Design Patterns rules: The definition of each pattern is based on some rules that must be satisfied in order to make the decision that a specific pattern is suitable enough to be applied for the solution of a problem. For the better understanding the following example is given: In literature the factory pattern is defined by the following rule: “*when a container contains functions or subclasses (nodes) that are objects of the same class then Factory pattern can be applied*”. For example the class automobile can contain the subclass Ford, Toyota etc. In that case automobile is the container and each subclass is a node connected to the constructor of the container (*Sample of rules for particular patterns in Table 1*).

Recommendation of Design Patterns Based Context Elements and Utility Function: With this method the recommendations of Design Patterns are produced based on the users’ preferences. The System provides to the user a set of predefined contextual elements for which the user is able to define the importance weight value for each particular element. The context aware recommendation method takes into account the user’s input and produces its results based on the output of a utility function. Thus the context aware recommendation result vary according to which context element is considered as important by an individual user and to what is the importance level in relation to the received recommendations.

Each methodology is used based on the phase of the design and the available contextual information but in that case the selection of the methodology is

determined only within the design editor sub-tool of the prototype. The Design Patterns were selected from the GoF [2] list of patterns and modelled in a separate ontology that is queried according to needed recommendation methodology input.

6 Future Work

The remaining work for the completion of this research work is mostly related to the Evaluation Objectives. We currently organize the evaluation sessions with professionals Software Architecture Designers from corporate organizations as well as academic ones. The evaluation will be done in a controlled environment, using specific use case scenarios and specific problem statements. That way we aim to collect feedback from the experts regarding the experience and usability, the accuracy of recommendations, the impact of recommendation in the creativity design, the usefulness of the tool and finally whether the social attributes of the prototype facilitated overall process.

By the completion of this work we will have the following accomplished tasks:

1. The creativity ontology model, which will be available to be used for other CSTs, The Design Patterns Ontology, a Semantic Web Application having a SAD knowledge Base and a graph editor supported by recommendation types that facilitate the creative process of SAD and finally three new methodologies for the recommendation of Design Patterns.

Finally, the analysis of the results regarding the users' satisfaction and the prototype usefulness, as well as the validity of the context aware recommendations of Design Patterns will lead into important conclusions regarding the main objective of the current work, which is whether the provision of context aware recommendations during a creative process such as the Software Architecture Design improves the creativity of the designers.

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