The Observable Creative Process and Reflection-on-action

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ABSTRACT
The way in which creativity support tools guide creative thinking as well as the externalisation of it largely remains an unanswered question. Creative professionals should be aware of these effects so that they can better develop their practice. The proliferation of software in the creative process provides opportunities for the development of features that allow professionals to reflect on the creative process and thereby to improve this awareness. This work proposes a methodology for capturing and analysing creative processes that are mediated by creativity support tools. The captured data is described in terms of an ontology and the analysis of the data is based on a sequence-detection algorithm. The methodology is expected to lead to insights into the role that creativity support tools play in the creative process as well as to design guidelines for representations of the creative process that are useful for reflection.

Author Keywords
creativity, evaluation, innovation, art, design, user studies, ontology, observable creative process, reflection-on-practice, workflow sharing, creativity support tools.

ACM Classification Keywords
H.5.2 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: User Interfaces

INTRODUCTION
In the study of the phenomenon of creativity there is much attention for its societal, social, and cognitive aspects, but arguably there is a lack of attention to how a personal creative process is brought into the world and what role software tools play in the externalisation of that process. Csikszentmihalyi [4] provides an account of the systemic properties of creativity that underlines the importance of the domain, that is the background knowledge, and field, that is the community that assesses, to creative activities and outcomes. Boden [1] emphasises that personal creativity is different and that its cognitive aspects can be studied through computational modelling. However, the externalisation of cognitive creativity, which is a necessary step for it to be assessed by others, is a process for which little theory has been developed. What are the general qualities of this process and what is the role of externalisation and reflection on the externalised in the cognitive process of creativity? Schön [11] characterised the design process, which is arguably a creative process, as a "reflective conversation with a unique and uncertain situation". His theory of reflection-in-action provides much useful language that is directly applicable to the discussion of the observable creative process.

In many design professions, such as architecture, 3D animation, or music composition, software tools are used extensively in the daily workflow. In many cases those software tools, or creative support tools (CSTs), accompany every stage of the creative process, from making sketches to post-production. The integration of CSTs in the creative process goes much further than being an extension of the body which allows for more efficient elaboration of a mentally achieved creative result. It could be argued that CSTs are explicitly represented in creative thought processes and that they guide greatly the externalisation of the creative process. The questions of how extensive this effect is and how aware of this effect the user is remain. Given that it is the process that determines the outcome, and that therefore creative outcomes depend on innovation in the process, then surely, in professions where innovation is important the practitioners should have a good understanding of this effect.

The study of CSTs aims to understand what qualities enhance, provoke, or disrupt creativity, with the aim of being able to design better ones [9]. The field of study has a clear focus on the observable creative process and studies in the field result in a) design guidelines, such as the user being able to make variations and switch between them [7], or b) in specific designs, such as easy previews of the effect of transformations [12]. In general, these methods aim to facilitate reflection-in-action, that is to allow the user to easily explore a design problem. However, supporting reflection-on-action, which is the reflection on a completed creative process, is generally not stated as a goal. Here we extend Schön's definition of reflection-on-action to include not only reflection on the result of action, but also reflection on the process that lead to that result.

The proliferation of software tools in the creative process presents us, not just with questions, but also with opportunities. As the creative process is mediated through software its externalisation can be logged and the captured data can be analysed. Although methods of studying user behaviour in the field of human-computer interaction through logging are not new [8], such an approach still has much to offer the study of the creative process. Not only could it provide a deeper fundamental understanding of the creative process, but it could also lead to features that allow users to more easily reflect-on-action. That is, if much of the observable creative process is captured then it can be represented to the user visually or otherwise. As argued

earlier, innovation of the process is important in creative professions, and therefore awareness of the process is too. Reflection-on-action is the manner in which this awareness is cultivated and as such CSTs should include features that facilitate this. Furthermore, the degree to which CSTs support reflection-in-action should be included as a measure in their evaluation.

There is no reason why reflection-on-action assisted by representations could not be done by persons other than the original actor. In fact, the possibility of having access to information about the process of someone else might be an even more compelling reason for considering implementing reflection-on-action features in CSTs. Consider, for example, a student of composition who has a complex homework task. For the teacher being able to discuss in class the process by which the student completed the homework with the help of a visual representation could help greatly. Also, web-based communities, such as Instructables[1], where users share workflows and know-how could benefit greatly from having their creative processes automatically described and visualised. In such cases, the creativity of the community as a whole could be advanced. In a similar fashion the sharing of scientific workflows has been argued to have tremendous potential for scientific advancement [5].

Finally, it is the position taken here that a) the externalisation of the creative process should be examined more closely, b) that CSTs should explicitly support reflection-on-action, and c) that a promising strategy is to do so through log studies following the methodology described below. Currently this methodology has not been implemented and remains a proposal. It is however the intention of the authors to realise it in future work.

METHODOLOGY

Ontological Approach

The CST, viewed here as mediating between creator and artefact, can be seen as a description of the creative problem domain. Its affordances are implementations of frequently used sequences of actions and transformations and therefore embody the knowledge of a practitioner. As such, the affordances of the software tool can be described formally in an ontology that can be taken to describe the domain. These concrete affordances can then be grouped in abstract classes and organised in a class hierarchy. An example of such an affordance is the scaling of the X dimension transformation that can be applied to geometric primitives in 3D modelling tools. This scaling transformation would be grouped together with the scaling transformations for the other dimensions.

It is important to note that these affordance classes do not map directly to UI events, such as button clicks and number field input, but that these events bring into existence instances of these classes. It is possible that an analysis of events on the level of UI interaction will reveal vital information and therefore it is required that the ontology incorporates concepts to describe UI events as well as concepts to map these events to the higher level concepts of affordances.

The underlying reason for the development of this ontology is to have the ability to describe the observable creative process, which is constituted by the actions taken by the user within the CST. The order in which these actions occur is the defining feature of the process and therefore the ontology should include concepts that can describe time ordered structures of events. In addition to time ordering, there will also be a hierarchical ordering of actions for which the ontology will need to account. For example, transposing a part of a melody in a midi sequencer such as Logic consists of several UI events. Several ontologies for describing production workflows exist, such as the Music and Studio ontologies [6,10], but the concepts included are too coarse to describe the granularity of action in the processes that are of interest here.

The context in which actions occur is key to understanding them [8]. The time ordering described above is one aspect of an action's context, but equally important is the relation of an action to the artefact which is being built. If the affordances of a tool are seen as transformation on a structure, a description of an action will only be complete if it maps an instance of an affordance to the part of the structure to which it is applied and therefore the ontology will need to support such mappings.

Once the ontology has been developed the CST will need to be adapted so that the actions taken in the tool can be captured and stored.

Data Collection

At this point users should be invited to use the CST in a controlled environment. In addition to capturing the observable creative process as described above other data collection techniques should be employed as well. Video recordings of the desktop and of the user will help greatly in the interpretation of the process data. Also, from the video recordings information about the user their thoughts and experience can be obtained by joint observer and participant interpretation [8] or by user or expert reflection [3].

Analysis

The aim of the analysis of the data is to look for sequences of actions that are typical for the observed creative process as this will characterise it best and therefore give both researcher and user insight. Quantitative analysis of the data, such as the frequency of use of affordances, will undoubtedly provide insights as well, but it is expected that qualitative analysis will be more helpful. For example, a

[1] http://www.instructables.com

user will be hard pressed to know what he should improve and how from statistical descriptions alone. The collected data will have several qualities that will make qualitative analysis easier. It will be a) highly structured in terms of time ordering and hierarchy, b) described at a semantic level due to the use of an ontology, and c) highly granular as it includes all UI events.

Because of the granularity and amount of the data the detection of sequences is expected to be achievable only through computational methods. Furthermore, there are several techniques that a sequence-detection algorithm can apply to the data so that it can detect sequences that are equivalent at different levels of abstraction. This is necessary as the algorithm would otherwise likely only find very short and very few sequences that are exactly equivalent, and not any sequences that are in fact semantically equivalent. The algorithm should look for repeated occurrences of sequences employing all of the following strategies:

- *Summation*: Two or more subsequent actions of the same affordance class can be combined into one action with a functionally equivalent outcome. It is important to note that in the summation of transformations vital information might get lost. For example, the repeated nudging of an item left and right might ultimately sum up to no transformation at all. However, the repeated nudging might indicate a process of fine-tuning, which should be recognised as such.
- *Ignoring or segmenting the parameter space*: If two or more actions are of the same affordance type and the affordance class includes parameters then ignoring some or all of the parameters can lead to making the actions equivalent. Also, the parameter space of the affordance can be segmented, possibly by clustering, and the values for the parameters can be replaced by the segment its symbolic name.
- *Abstract classes*: The affordance class of an action can be replaced by one of its super classes, which has the result of making affordances that are described by the ontology as being similar equivalent.
- *Grammars*: Rewrite rules can be used to define equivalent sequences of patterns [8]. It allows for domain specific knowledge to be incorporated into the sequence-detection algorithm.

The development of the sequence-detection algorithm and rewrite rules should be inspired by the data collected from the aforementioned joint participant and observer interpretation. Similarly, the results of the algorithm should be consistent with this data.

It is expected that findings at this point will lead to improvements of the analysis method in an iterative manner. Hopefully the results of the analysis will lead to an enhanced understanding of the creative process as it is externalised through software tools. Also, any findings will inform how to visualise or otherwise represent the observed creative process to users.

Experiment

As mentioned in the introduction a key reason for proposing the methodology described is to give the user the ability to reflect on their creative process as it is the contention that it will help them to develop their creativity over time. With the insights gained from the data collected and analysed visual representations of that data can be developed. The hypothesis is that there will be a measurable difference in user behaviour when they have the ability to explicitly reflect on their own creative process with the help of visualisations.

To be able to measure this hypothesised change a first set of users, Group A, will need to participate in several sessions. After each session the users will be asked to reflect on their own creative process with the help of visualisations. A second set of users, Group B, will go through the same sessions, but will not get the opportunity to reflect. An analysis method will need to be developed that can characterise processes at a high level and can show that there are differences between the processes from the later sessions of Group A and Group B.

In addition to looking at the differences between processes, an ethnomethodological approach can be taken to look at how users interact with the visualisations. Finally, through questionnaires or interviews users could be asked what their opinion or experience of interacting with the visualisation was. Of special interest is whether users will have become more aware of what their process has been; that is whether it has helped them reflect-on-action.

DISCUSSION

There is an important difference between the methodology used in usability studies that use data collected through logging and the methodology proposed here. Whereas in a usability study one will tend to look for problems with the interface, these problems are not the subject of investigation here. It is the process itself and its intrinsic qualities that are of import.

The ontological approach to the description of creative processes brings with it some disadvantages that are worth mentioning. First of all, whoever develops the ontology needs considerable knowledge of how the CST works and of the creative problem domain the CST is designed to address. Secondly, in ontological work there are often multiple valid but different ways of describing a concept and it is therefore difficult to evaluate the developed

ontology [2]. Lastly, it is unclear how much of the ontological work can be reused for other CSTs.

As mentioned in the introduction, the proposed methodology is mainly concerned with CSTs that are used by professionals. The majority of these tools are commercial and closed sourced software and are therefore unlikely candidates to be picked as focus of this methodology. If an open source CST is picked it is however important that a) it is comprehensive in the sense that it has a similar feature set to its commercial counterparts, and b) it has a large enough user base to find participants for the experiments. If a CST is not comprehensive it cannot be used from start to end of the creative process and as such the captured data will be incomplete either because the process cannot be finished or because for some parts of the process other tools were used.

Although to some degree the difficulty of adapting a CST depends on the complexity and source code quality of the software, for any reasonably comprehensive CST this will be a time consuming task. It seems a good strategy to implement as much of the supporting functionality, such as storage and analysis of data, as possible in a service oriented architecture and thereby keeping the adaptations to the CST to a minimum.

The proposed methodology is a risky endeavour because of several extensive preparatory steps that will need to be taken, such as the development of the ontology and the adaptation of the CST. On the other hand, it could result in valuable insights into creative processes as well as useful new functionality for users.

CONCLUSION

In many professions CSTs are used extensively in all stages of the creative process. However, the role CSTs play in the externalisation of the creative process is not well known. Similarly, CSTs guide creative thinking and therefore both enable and limit it. For creative professionals it is important to develop their creative processes and they should be aware of what they are and how CSTs influence them. CSTs should therefore include features to make this reflection-**on**-action possible.

Furthermore, a methodology is proposed for capturing and analysing observable creative processes. It is based on the development of an ontology, which describes the affordances of the CST and the domain of creativity. The ontology should also include concepts that describe events and their chronological and hierarchical ordering, UI events, and links to part of the structure of the artifact that transformations are applied to.

Also, an abstract sequence-detection algorithm to find repeated occurrences of sequences of actions is described. It can employ techniques such as summation, ignoring or segmenting the parameter space, substitution by abstract classes, and rewrite rules to find sequences of varying equivalence.

Findings from the development of this analysis method are expected to lead to insights into the creative process and to inspire ways of representing it to the user. Finally, these representations and their usefulness will have to be evaluated in their own right.

ACKNOWLEDGMENTS

Support from the Media and Arts Technology Programme: An RCUK Doctoral Training Centre in the Digital Economy.

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