School of Informatics

Informatics Project Proposal
A Systematic Review of Electronic Brainstorming Applications and their Incorporation with Machine Learning

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Abstract

Among the different approaches to brainstorming is the use of electronic tools with variants ranging from web, mobile to desktop applications. Despite the extensive theory on brainstorming and electronic application evaluation, there remains a glaring lack of design guidelines or an evaluation framework for brainstorming applications. This project studies relevant research literature to understand requirements of such applications. We combine this knowledge with user input to formulate an evaluation framework which we use to systematically analyze selected applications. Finally, we propose a machine learning algorithm that collates and displays related information based on user input during a brainstorming session.

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1 Motivation

Brainstorming is a method used by an individual or a group of people to capture ideas, devise or refine existing solutions about a specific area of interest [1]. It is characterised by a spontaneous generation of ideas for potential solutions before considering some of them more carefully [2, 1]. Individual brainstorming is such a process in solitary situations performed by a person by jotting down ideas, free speaking or drawing mind maps whereas group brainstorming involves more than one person. It follows that electronic brainstorming (EBS) is the use of technology-based tools like mobile, web and desktop applications for brainstorming.

Implementation of EBS tools has been facilitated by advancement of application development and further propelled by its potential to bridge gaps existent in classic brainstorming techniques by using technology[1]. In spite of the promise offered by EBS, its adoption in fields like academia is limited. This is a systematic review to analyze *what* has been implemented for EBS specifically for academic settings. We begin by extensively studying the relevant research literature and combine it with user input to establish what should be implemented in these applications. With this understanding, we formulate an evaluation framework that we use to assess selected applications. Based on the evaluation, we suggest guidelines to design EBS tools. Finally, we make a contribution to the state of the art by exploring *how* machine learning can be used to optimise EBS tools to enhance brainstorming in academia. Since the project focuses on EBS in academic settings, we denote electronic brainstorming tools for academia as EBT in the subsequent sequel.

1.1 Problem Statement

Electronic brainstorming has been well researched on and articles have been published reviewing existent brainstorming methodologies [4, 5, 6]. Notwithstanding, neither has a systematic review on EBT been conducted nor a framework formulated to specifically evaluate them. This review aims at improving the understanding of currently implemented EBT by combining research literature with user input to answer the following question:

[1]Classic brainstorming techniques are approaches that do not primarily use electronic-based tools as during a brainstorming session [3]. An example of how EBS bridges gaps can be seen in its use by geographically dispersed teams to hold brainstorming sessions online. This cannot be achieved using classic techniques.

What is the state of the art in electronic brainstorming for academia, to what extent do current EBT adhere to brainstorming research literature and how can these tools be improved to enhance electronic brainstorming?
In order to comprehensively answer this question, the following sub-questions arise:

1. What guidelines have been set out in research literature on brainstorming and electronic brainstorming?
2. To what extend have the current EBT been designed to capitalize on progress made in brainstorming research?
3. How can the current EBT be enhanced in order to improve brainstorming and idea generation in academia?

1.2 Research Questions and Objectives

The prime objective of this project is to understand how the current EBT have been developed in relation to what has been studied in brainstorming and electronic brainstorming. On this basis, we begin by perusing research literature on brainstorming, electronic brainstorming and application evaluation. This knowledge helps to formulate an evaluation framework that we use to answer the following questions:

Question 1: What are perceived as advantages of EBT over classic brainstorming technologies?

Question 2: What criteria can be used to assess the perceived advantages of EBT?

Question 3: What are the best EBT?

Question 4: How can machine learning be used to improve the best EBT?

We proceed to systematically review selected EBT to identify their advantages and common pitfalls which direct us to come up with design guidelines for such tools. Based on this review, we introduce Electronic Brainstorming with Machine Learning (EBSML), which is an integration of machine learning algorithms with brainstorming applications to enhance brainstorming, idea generation and selection by displaying real-time suggestions based on user input[2].

The **objectives** of the project are outlined below:

1. Review of research literature on brainstorming, EBT and creativity and the theories behind them.
2. Create a framework of evaluation based on the studied literature and user survey.
3. Conducting a systematic evaluation of EBT.
4. Derive a set of recommendations and guidelines for implementing such tools.
5. Build an algorithm implementing EBSML. Time permitting, an interface modelling this prototype will be built.

1.3 Timeliness and Novelty

At present, there are numerous EBT that have been developed. However, there is no systematic review has been conducted for such tools nor is there any evaluation framework to analyze them. We attempt to fill this gap by establishing an evaluation framework and suggesting guidelines on how to design and develop EBT.

[2]Suggesting feasible information during a brainstorming session is called priming and is further elaborated in Section 2.

Secondly, EBSML capitalizes on extensive research on text mining, information retrieval [7, 8] and the maturity of application development that enables the integration of machine learning algorithms with EBT. Building on this progress, we suggest an enhancement to EBT that utilizes machine learning to stimulate the creativity of users during a brainstorming session.

1.4 Significance

Formulating an evaluation framework and design guidelines contributes to the state of art in the domain of electronic brainstorming. Secondly, embedding machine learning in EBS typically requires customised algorithms as it is a particular application of text mining and information retrieval. This opens up a new area of research for data scientists and application developers.

1.5 Feasibility

The project has four well-defined stages. Initially, a review of research literature on brainstorming technologies is conducted and is succeeded by the formulation an evaluation framework for assessing EBT. We proceed to carry out a systematic review of brainstorming technologies. These guidelines usher in the fourth and final stage, building a machine learning algorithm that implements EBSML. We are guided by [7] who explores analysis of input text and correlating it with archived information. Although this has not been specifically explored for electronic brainstorming, it seems like a plausible application of machine learning.
The timeline for these stages is detailed in Section 6.

1.5.1 Risks

Stage	**Risk**	**Mitigation**
Literature review	1. Too few articles on EBT	Counterbalance with a user study to find out more about perceived advantages of EBS.
Systematic review of tools	2. Few participants for user study 3. Too many EBT available	Collate information from related studies. Employ selection criteria described in Section 3.
Prototyping	4. Infeasible algorithm for EBSML 5. Unable to prototype due to time	Provide findings and challenges encountered. Suggest guidelines for building such a tool.

1.6 Beneficiaries

This project will be beneficial for EBS users, application designers, researchers and persons conducting systematic reviews of EBT as discussed below:

- Application analysts assessing EBT can refer to the findings, evaluation framework and guidelines emerging from this project to guide their evaluation.
- Application designers and developers intending to implement EBSML can follow on the algorithm built during this project to build enhanced EBT.
- Users' experience will be enhanced by improving current EBT based on the findings of this project. Applications built on the recommended guidelines will prompt users to generate ideas seamlessly and select the most feasible ideas faster.

- Data scientists can build on this project to instigate formulation of better algorithms that are optimised for EBT applications.

2 Background

Electronic brainstorming has been implied to be the most effective implementation of capturing, evaluating and selecting generated ideas during a brainstorming session [4, 5, 9]. This high status, however, comes as a consequence of progressive research and well-thought out designs. Studies have been conducted on how to utilize technology to improve brainstorming and idea generation. One such study is by Minas et al. [4] who explore the effects of priming in EBS. They describing priming as an intentional influence on an individual's cognition to trigger creativity by using pictorial illustrations or related words. According to their study, incorporating related suggestions during a brainstorming session potentially hastens the rate of idea generation as well as leads to an improvement in the general quality of ideas produced. They highlight that effecting priming during a brainstorming session is a significant enhancement to the entire process.

Beyond such enhancements, a study by Brent et al. [5] showcases the potential of EBT to mask inherent personality traits and social cues that inhibit idea generation when using classic techniques. In their survey, large enough groups (of 6 or more people) that held brainstorming sessions using classic means were not as productive as those that used electronic brainstorming techniques. They attributed the difference in generated ideas to the impact of personality traits and social interaction. Electronic brainstorming enables participants of a brainstorming session to collaborate online with much personal interaction. The significance of this is that participants can generate ideas without the aforementioned influence on their creativity. This indicates another advantage induced by EBT.

Comparisons between different brainstorming technologies have been drawn by Pinsonneault et al.[10] where they evaluate pros and cons of various brainstorming technologies. A highlight of their study is that for every enlisted advantage, an electronic tool registers. This is significant because it studies on ways in which to implement an EBT in order to maximise on advantages and subdue drawbacks by building dynamic applications that can be adjusted according to context or participants of a brainstorming session.

In spite of how well implemented an EBS application is, an important observation by Adams [11] on the combined effect of perceived usefulness and perceived ease of use suffices. The study pits two unfamiliar graphic systems against each other to students as a way of distinguishing the impact of perceived usefulness and the perceived ease of use. The results show that "only perceived usefulness determined their intention to use the software". This implies that the choice of which brainstorming technology a user makes tends to rely more on how effective it is rather than how easier it would be to use. A user of an EBS tool needs assurance that the application delivers on the requirements even before learning how to use them.

Building on these findings, there seems to be an underlying consensus that if well implemented, EBS has the potential to not only mask flaws inherent in classic techniques but also to significantly improve the process of brainstorming and idea generation [4, 5, 6]. Among others, these studies and suppositions reveal *what* the requirements of effective EBT are and guide our systematic review in finding out *how* these tools should be implemented.

3 Programme and Methodology

In essence, a systematic review entails a clear-cut procedure of evaluation. In this regard, the review advances following the steps listed below:

1. Familiarisation with brainstorming - We review the literature to deeply understand brainstorming and creativity and the theories behind them.
2. Formulation of an evaluation framework based on research literature and user study.
    i Research literature - Building on bullet 1 above, we formulate a framework of evaluation that adheres to the guidelines set by state of the art research.

ii User study - We define a group of students who frequently hold brainstorming sessions for their academic work. They are to evaluate three differently implemented EBS applications with differing structures and/or interfaces. Based in their experience using these applications, are to convey requirements and specifications for EBS applications. Evaluation details are in Section 4.

3. Conducting an EBS evaluation - This involves the inclusion and exclusion criteria and a systematic evaluation of tools.
   (a) Inclusion criteria - The decision on which applications to evaluate and which to exclude will be informed by the result of a ranking that we define. Weighted scores are awarded to every application based on the following:
      i. We employ results of recent findings from bullet 1 that conducted surveys to establish which tools were deemed popular.
      ii. Applications that are best indexed by search engines.
      iii. Applications recommended by relevant research literature that was reviewed in the first bullet.
      iv. Applications built specifically for brainstorming in academia - This criterion is included because the project focuses on brainstorming for academia.
   (b) Exclusion criteria
      i. Cost - Some tools require subscription fees in order to gain access. This is a stumbling block for this project.
      ii. Language - Brainstorming applications that are developed in languages other than English will not be evaluated
      iii. Tools that require to be installed in operating systems other than Linux and Windows for desktop applications and iOS and Android for mobile applications will be excluded because the required resources are unavailable.
4. Derive a set of recommendations and guidelines - From literature review and application evaluation, we identify common pitfalls and recommend on best practice to adapt in order to improve current EBS applications and for future designs.
5. Devise an algorithm that implements text mining and information retrieval in electronic brainstorming applications.
6. Prototyping and evaluation of the prototype - Time permitting, we construct a prototype that models EBSML and invite users to evaluate the prototype.

3.1 Novelty

1. Implementation guideline - After reviewing research literature on electronic brainstorming and conducting a user study, we offer a guideline that can be used to design EBS applications.
2. Evaluation framework - Based on findings of the project, we suggest a set of criteria which can be used to assess EBS applications.
3. Electronic brainstorming with machine learning - Machine learning technologies have made it easier to efficiently make correlations between features. We investigate the feasibility of incorporating machine learning algorithms into EBS applications as an implementation of priming.

4 Evaluation

Evaluation in this project is in two facets; evaluation of EBT and evaluation of the prototype. For both, the evaluation criteria is explained.

1. **Evaluation of EBT**
   (a) User evaluation - A user study will be conducted to capture user reviews on the selected tools. The web platform Ona [12] will be used to guide users on how to access the applications and

will host the forms with which to responses will be collected. Users are asked to rate the tools in based on the following criteria:

i. Usability
   - Navigation and responsiveness of application interfaces
   - Readability of text and background contrasts
   - Illustration of ideas and implemented data-flow diagrams of the system
   - Availability of support bots or on-screen instructions and guidelines of use

ii. Availability
   - They explore each tool on its implementations for a desktop application, smartphone applications, web interfaces and compare how well the features interact across these three platforms.
   - Offline usability. If the application has mobile and desktop versions, how well do they function without an (stable) internet connection?
   - Multilingual support.

iii. Data management
   - Export formats - How do the tools support data exports? PDF files, pictures, links etc.
   - Import options - Do the tools allow embedding and/or tagging external resources for reference? Pictures and icons, documents, URLs etc.
   - Back-up options - If the tools have installed versions, how often do they synchronise with the server to ensure proper and reliable data back up?
   - Data protection and security - Do these tools abide by the stipulated data protection rules?

(b) Systematic evaluation

i. Multi-user functionality. A proper EBS application should support multiple users working on the same page in real-time. This needs an implementation of an application that allows:
   - Concurrency control - To address conflicts arising from simultaneous access or alteration of data that can occur within a multi-user system.
   - Version control - A vital component for a system implementing multi-user functionality because making updates on the same page might cause irreversible and unintended loss of information [13].

ii. Context flexibility. Is the application as useful when used in an academic context as it is when used in a other domains? It is worthwhile to find out if tools optimised for particular domain are as useful in other contexts or if a well implemented application is good enough for all contexts.

2. **Prototype evaluation** - If a prototype demonstrating assisted brainstorming is built, a miniature user evaluation will be carried out to establish how beneficial the model is and get their recommendations for future implementations.

5 Expected Outcomes

1. Evaluation framework - This will be derived from guidelines established in the relevant literature and the conducted user study.
2. Evaluation of tools - Using the obtained framework, we assess the applications that have been developed for electronic brainstorming.
3. We lay out a set of guidelines and recommendations to be followed while designing EBT.
4. We design an algorithm that implements real-time text mining and information retrieval in EBS. Time permitting, we build a prototype's interface modelling an EBSML application and organize for a miniature user evaluation from which we avail empirical data outlining the acquired feedback.

Enabling predictive packages into brainstorming applications is expected to be an upgrade in brainstorming for academia because research progresses on built up knowledge. Therefore, collating related concepts and ideas during a brainstorming session is likely to have a positive impact in invention and in

devising new ways of solving academic problems.

5.1 Contribution

This project adds on to the knowledge and theory of electronic brainstorming by proposing an evaluation framework with which to assess EBT. Further, we explore the feasibility of embedding machine learning algorithms in EBT as an implementation of priming. We build an algorithm for electronic brainstorming with machine learning and conduct a user evaluation of the model for a critical and complementary appraisal.

6 Research Plan, Milestones and Deliverables

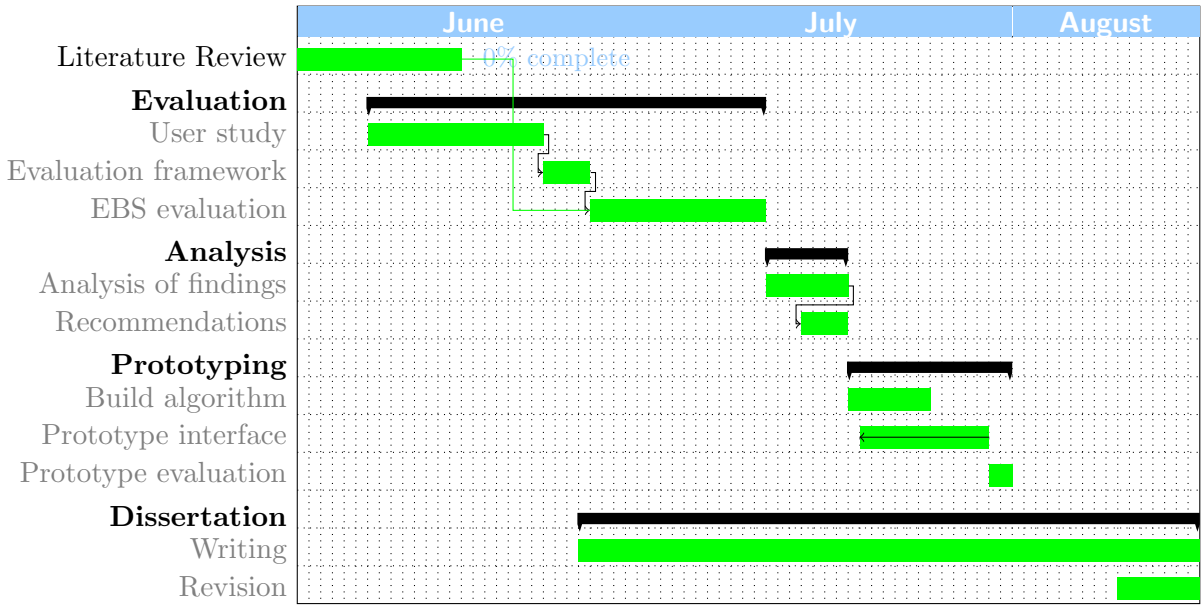

Figure 1: Gantt Chart of the activities defined for this project.

Milestone	Week	Description
M_1	3	Literature review completed
M_2	4	User study and evaluation framework completed
M_3	7	Analysis of findings completed and recommendations drawn
M_4	9	Algorithm and prototype interface completed
M_5	10	Prototype interface evaluation completed
M_6	11	Submission of dissertation

Table 1: Milestones defined in this project.

Deliverable	Week	Description
D_1	3	Comprehensive overview of state of the art
D_2	4	User study data and an evaluation feedback
D_3	7	Results of analysis
D_4	9	Algorithm and prototype interface
D_5	10	Empirical evaluation data of the prototype
D_6	11	Dissertation

Table 2: List of deliverables defined in this project.

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