An Intelligent System based on Natural Language Processing to support the brain purge in the creativity process

Fadi Issa, Davy Monticolo, Alex Gabriel, Simona Mihaita

***Abstract*—The creativity phase is the first step of the innovation process. Indeed, the innovation process is based on a first idea. During creativity workshops, engineers work together in a collaborative way to generate new ideas. They follow the creativity process based on different phases: discover the topic, apply the creativity methods, generate ideas, formalize ideas, share and evaluate their ideas, then select the innovative ones. Up till now, the creativity workshops used simple tools like paperboards, post-its or idea sheets to capture ideas. These tools are not efficient in regrouping the ideas and categorizing them into clusters defined by some themes. In this paper we describe a Natural Language Processing based system that helps participants in creativity workshops to cluster and classify their ideas.**

***Index Terms*—Creativity, Semantic Similarity, WordNet, Multi Agent System, Idea Classification**

I. Introduction

Giving life to ideas and visualizing innovative concepts trough a numerical system can be a hard task to achieve in the scientific world. The process of generating new ideas involves mixing different concepts, such as: discovery, creation, sociability, refinement and communication.

Although in the literature the scientist have used more than 80 definitions to describe the creativity process [8], the most popular is the one given by R. Sternberg [23], stating that the "creativity is the ability to generate new useful things that are characterized by being novel and appropriate". This definition emphases the characteristics of the creativity process, as the results need to be adapted and related to the real-life experiment.

In general a creative work of art is considered to be the creation of an individual, but the most complex and innovative results have been obtained when there is a strong collaboration and interaction between different individuals who participate in the creativity process [12]. This is due mainly to the fact that each individual has his personal skills, originality, knowledge and expertise which will enrich the creative solutions and easily build the road towards creative and sustainable solutions [1].

Furthermore, when establishing scientific collaborations between computer scientists and domain specialists, a significant acceleration of the development of a project can be observed, compared to the work of a single artist/scientist [28]. The collaboration process can be done using different creativity support tools, which need to be adapted to the nature of the project under construction. With the help of today's modern computer-based environments, the user's capability to discover and invent can be improved, even from the early stages of the innovation process. Adapted applications can guide the used to generate ideas, formulate clear hypothesis and different working alternatives, gathering proper information until the later stages of validation, refinement and completion of the creativity process.

Due to an increasingly competitive production industry, concepts such as creativity and innovation have gained popularity, but the topics are quite new in the field of computer and information science. As a standing proof of the interest given to the creativity process, we can cite several excellent books on creativity [14][11][19]; unfortunately none of them relate to the terms of "computer tools", "user interface", "interactive collaboration".

According to Ben [3], when building innovative creativity support tools, there are some principles that should be respected, as the tools must : support the exploratory search (search services which allow ranking, clustering, organizing and marking), enable collaboration in the community of social creativity, provide rich history-keeping, provide an easy design tool which can be easy to learn and apply for beginners.

The organization of collaborative meetings is usually done in advance, and placed in co-located settings. But the progress of the meeting can be achieved in a spontaneous way, as the individuals working together have a natural tendency of quickly exchange opinions.

Studies have shown that individuals working together and using traditional communicating methods such as: pen and paper, printed documents, reports, paperboard, tend to better

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organize their ideas and thoughts around horizontal surfaces (tables, desks) [21]. But when moving to digital media (getting around a PC or working separately on their own laptop, listening to a video-conference), people lose the feeling of having a comfortable and a productive collaboration. Recently, several research studies focus on how to choose a modern interactive tool (or even a collaboration ecology) which simulates the creativity collaborations [24][13][17].

Nowadays, the creativity is considered to be the key to new successful ways of conducting a project, either it's in the educational field (professors looking for new teaching methods or student projects) or in the business domain (companies seeking for success through innovative products). As a consequence, many companies and professional freelancers invest in the training of their employees, by participating in creativity workshops, under the supervision of a creativity expert which leads the way through the workshop. As an example, the ArtScience Annual Innovation Workshop[1] hosted by Le Laboratoire in Paris, France, gathers students from all around the world towards highly innovative art and design ideas at frontiers of science. Another example of educational creativity workshop is the annual Creative Practice Bootcamp[2] wich is held in Nashville, TN, where students learn how to apply creativity methods such as Brainstorming [9], Brainpurge [25] or Brainwriting [10]. We can also notice an increasing number of companies which get involved in the business creativity workshops, as they seek for new ideas in order either to develop their products, or the marketing strategies. Such an example is The Creative4Business Workshop[3], held regularly in different cities around the world, which aims at helping the participants to generate, filter and extract the most original ideas. But all of the above mentioned workshops relate to the traditional pen-and-paper methods, not being able to process and to filter ideas automatically as the creativity process unfolds.

Two of the most utilized creativity methods are the Brainpurge and Mindmapping [5]. Recently, S. Buisine proposed in [4] an experiment based on these two methods: they used an augmented multi-user tabletop system DiamondSpin Toolkit [22] on which they carried creative problem solving sessions; the same sessions were carried out using pens, paper, and flip charts [25]. Finally, the subjective evaluation showed mixed results because the majority of the users preferred pen-and-paper for the Brainpurge, but were using the digital tabletop for the Mindmap method.

The above studies and experiments lead us to propose an intelligent system which is able to classify, regroup, and make links between new ideas which are generated during the Brainpurge method, in order to automatically build a Mindmapping afterwards.

The second part of this paper presents a state of the art of the creativity methods and the creativity support systems that already exist. The third section of our paper describes our approach for building an intelligent system based on natural language processing, and the fourth section presents the model we use to apply our approach. The last section details the results we had during a creativity workshop.

[1] http://www.artsciencelabs.org/the-labs/
[2] http://curbcreativecampus.org/project/boot-camp/
[3] http://www.creative4business.co.uk/masterclasses/

II. Creativity Methods

A. Collaborative Creativity Process

Creativity is a subpart of the innovation process which can be considered as a result (that permits to qualify an object or a service as creative), or as a process itself[7].

Numerous models have been created to describe the creativity process, firstly according to the individual experience, as the Wallas models which contained 4 steps: (1) preparation, (2) incubation, (3) illumination, (4) verification, and secondly, according to a collective approach based on interaction and group dynamic as the Osborn's Creative Problem Solving (CPS) model [15]. The latter has been improving and getting modified in time and by different authors. The one which we considered here is the five steps CPS which is composed by the following steps: (1) finding the facts, (2) finding the problems, (3) finding the ideas, (4) finding the solutions, and (5) finding an acceptance [20].

In the literature, we observe different strategies to assist a group into the generation of ideas. Some strategies are based on heuristics and allow to describe the "design space" according to simple rules [29]. Innovation methods such as as TRIZ or creative methods such as SCAMPER can be classified as heuristics [29]. In opposition to these approaches based on rules, there are certain techniques based on the fluency of the team members. These strategies have been classified into five categories [2]: associations, analogies, bending, oneiric, and forced meeting. For instance, brainstorming and all its variants, as brainwritting [2], Brainpurge [25] and 635 method [2] can be classified as an associative method.

B. Systems for supporting the creativity process

Recent studies [20] have shown that the creativity method starts with the brainstorming, and different configurations are being experimented according to the support which is being used, the sharing of ideas or the composition of the group. This is known as Electronic Brainstorming System (EBS)[30]. Furthermore, the Mindmapping technique was adapted to computers, and more recently, heuristics methods such as TRIZ[6]. All these attempts to help the creativity through the computer is a part of a more general approach which is the Computer Assisted Creativity (CAC)[18] which attempts to give technical assistance to humans in order to stimulate their creativity [16].

Globally, the creative support evolves from a single technical support to a more general approach that brings organization and communication through the Group System Software (GSS), the Computer-Supported Cooperation Work (CSCW), or even the Idea Management System (IMS)[27], which are more oriented towards Knowledge Management. A mixed approach of all the previously presented methods is given by the Creative Support System

(CSS)[26].

Current works have been concentrating on creating a system which will bring methodological, organizational and communicational support to the creativity process through an agent-based system, which will manage and deal with all the knowledge created during the creative challenge. Three main actor configurations have been brought out: all of the actors are on the same place, part of actors are separated and all of the actors are in separate places. According to these different configurations and the degree of assistance which is needed, the system will adopt different automatic strategies.

In this article, the particularity of the system concerns the brain purge which is a creative technique applied at the beginning of the creativity workshop. The goal of this technique is to purge participants from traditional and obvious ideas, even if the method can be used to generate rapid ideas [25].

III. Our Approach

In this section we describe our approach to help the creative participants to cluster and classify their ideas during a creativity session. We apply our approach to the brain purge method where the creative participants expose all their ideas regarding the proposed subject. The ideas are written with a sequence of words. Our approach is based on the identification of semantic links between these words and their clustering.

Our system follows a process of nine steps:

- *Step 1*: the system proposes to the stakeholders to write the subject in the system; by stakeholders we denote the persons establishing the subject (the main theme) on which the creativity process will be applied.
- *Step* 2: the system proposes to the stakeholders to define the keywords that they are interested in;
- *Step* 3: the system builds the ontology about the themes by searching the semantic links in the WordNet ontology.
- *Step 4*: the creative people write the words and build a cloud of words.
- Step 5: the application counts the words which have been introduced by the creative individuals and emphasizes the words when they are repeated.
- Step 6: the users connect the words according to personal and subjective criteria.
- Step 7: the application counts the links made by the users between the words: it counts how many links have been defined between two different words.
- Step 8: the system compares the links made by the users with the links of the ontology and will display the new relationships that haven't been discovered yet.
- Step 9: the system proposes new relationships which haven't been yet explored by the participants.
- Step 10: the users take into consideration the new suggestions made by the system.
- Step 11: the application will displays the mind mapping tree based on the above steps.

In the next section we present the algorithm we have used to realize the semantic regrouping between the words which have been proposed by the participant in the creativity process.

IV. Semantic Regrouping

In order to assist the participants during the brain purge method, the implemented system proposes a word categorization, which requires grouping synonym words, and connecting these groups (or words if there is one word per group) with links towards the semantically closest group. This will finally lead to several graphs or a single but bigger graph, in case all the words were related to each other in a way or another.

This step of word categorization (or regrouping) is only applied on the words which have been entered by the participants during the first step of the brain-purge method. The output of this step is a graphical representation of the relations among the entered words, with suggestions of group names or themes that were not brought up by participants, but instead, are found by the system through the word categorization phase.

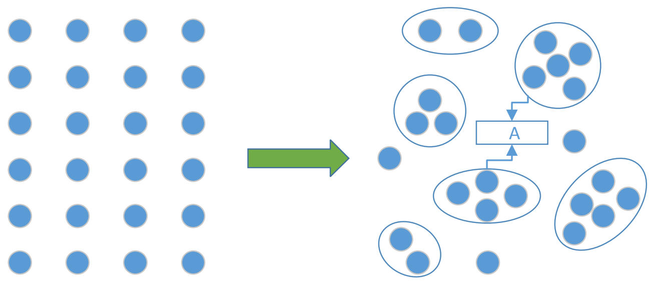

Fig.1 Categorization of words and theme suggestion

Fig.1 shows that, given a set of words, the system regroups them into categories and even suggests a theme that relates two groups (the *A* theme for example).

This regrouping and categorization can be of a great help for the participants as it suggests them some combinations of words that trigger new ideas in their minds, which should be added to the other generated ideas in this stage of the creativity process.

We enumerate several advantages for using the above described method:

- Some ideas would have never been discovered if this system categorization technique would not have been used, which fulfills one of the broad goals: coming up with new ideas.
- The human nature tends to forget the previous streams of words which have been generated during the purge creativity method, and instead they only on the latest streams (this was mostly observed in the workshops we held or participated in, such as the “48 Hours of Generating ideas” [31]). By using our approach, this problem is practically eliminated since the system takes all the previous words into consideration when doing the word categorization.
- If word regrouping is not applied immediately after the word collecting, but only when all the participants finish to generate their ideas based on their own perspective of the mind mapping method,

this step will suggest and point out new ideas and solutions of the targeted problem

In order to address this task of regrouping the words according to their relevance, we faced the following issues:

- Should we opt for a bigger number of fine grained groups, or for smaller but larger groups?
- Should there be some entered themes so that our system will try to relate each word to the closest theme? Or the system itself should offer to the user the themes of these groups?
- Will it be possible that an entered word will be a name of the group? Should we allow ongoing human intervention while generating the graph or leave the spontaneous creativity process continue?
- When should we consider that two terms are not related? Should it be flexible and dynamic? User defined? Or predefined and hard coded?
- The most challenging issue was to measure the relation between words, and translate these measurement into numerical data, so we can apply the comparing step between the words.

In our current approach which measures the semantic distance between two words, we used WordNet, which is a lexical database for the English language [32]. WordNet groups English words into sets of synonyms called *synsets*, provides general definitions and records various semantic relations between different sets of synonyms. These relations vary, based on the type of word. In this approach we use the hypernym relations, which is defined as: *Y is a hypernym of X if every X is a kind of Y* (for more details please refer to [32][33]).

When computing the distance between two words, we count how many links are required to go from the synset of the first word to the synset of the second word. For efficiency, we used the bidirectional search algorithm to calculate the shortest path between two synsets. It starts by searching for all hypernyms (for each of the two words) in the lexical graph of each word, by querying WordNet about hypernyms as needed; consequently it builds two graphs gradually, until a common hypernym is found between these two (Fig.2). This way we guarante that any two words will have at least one common hypernym, which is the root of the whole WordNet graph. After reaching the common hypernym, we calculate the number of steps it took to reach this common node from each word and sum up the two results. We apply this procedure to all the possible combinations between two words; for each word we choose the closest to it, and according to a user defined value, the system decides if these two words are in the same group or should be used separataely.

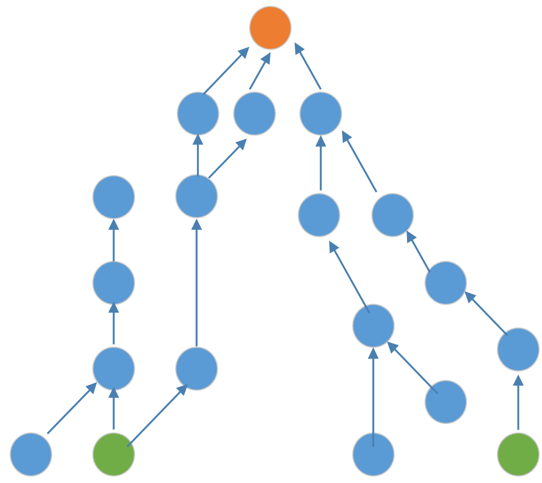

Fig.2 finding the first common hypernym of two words using bidirectional search.

For N words, we will have a number of pairs equals to:

$$\sum_{i=1}^{N-1} i = \frac{(N-1)*N}{2}$$

And for an average of M hypernyms per term, if the shortest distance between two terms is D, then the number of nodes required for search until finding the common hypernym is:

$$2 * M^{\frac{D}{2}}$$

This is a lot more efficient (in terms of speed and used memory) than if we start from one word, and keep checking for its related nodes till we find the target word. That approach would need M^D Nodes to search before finding the same result.

After finishing this step, the system connects the words according to their similarities (after applying some processing on the distance and normalizing it, so 1 is the highest score), then gives participants the choice of either accepting it, or modifying it according to their likes; they can merge groups, taking one word from a group and putting it in another group, or even change the theme names and ask the system to redraw the graph according to similarity with these themes. All of this is done on a touch screen which facilitates the Mindmaping method and makes it more intuitive while being enjoyable.

V. EXPERIMENTATION

We have experimented our approach during the creativity workshop “48 Hours to generate ideas” [31]. To support the creativity workshop we have developed a website called “48H Innovation Maker”. In this website we have integrated our approach to assist the regrouping of ideas. In our interface, the creative participants write all their ideas on the proposed subject using one word at a time. The main menu offers them three options:

- ***Words Form***: where they can write their words related to their ideas;
- ***Words Cloud View***: The system generates a Tag Cloud with the words proposed by the participants.

The Tag Cloud is based on the statistical analysis of the frequency of the proposed words. The Figure 3 shows an example of the Cloud Tag built for the creativity challenge: "How to help seniors increasing their way of life using digital systems?". We can observe the words "Assistant", "Digital", "Intelligent" and "Touch" are the most proposed by the participants.

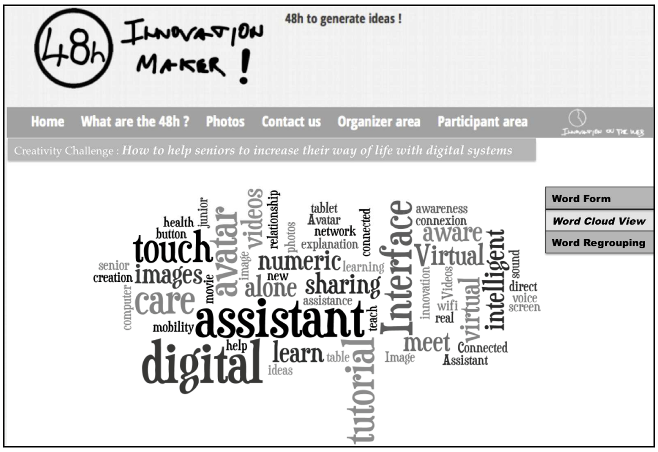

Fig.3 Word Cloud generated by the system for the subject "How to help seniors to increase their way of life with digital systems".

- ***Words Regrouping***: The system generates some clusters with the proposed words of the participant by using the semantic regrouping algorithm. Figure 4 presents the clusters generated for the above creativity challenge. The system calculates all the relationships between each word, and eliminates the words which have no relation with the cluster. The name of the cluster is taken from the words which has been frequently used by the users. For example, the two clusters proposed by the system in Figure 3 are called "Interface" and "Digital". Table 1 exposes the result of the algorithm for the cluster Interface.

Term A	***Term B***	***Semantic Similarity Score***
Interface	Touch	0,7
Interface	Avatar	0,6
Interface	Button	0,72
Interface	Awareness	0,7
Interface	Connected	0,68
Interface	Direct	0,5

Table.1 Semantic similarity score for the cluster "Interface"

We observe that not all the words which have been proposed by the creative participants were used in the Word Regrouping. Indeed, some words have no relationships with the others. The system cannot build a new cluster with those words. In our experiment, this is the case for the words "Alone", "Care", "Old", etc.

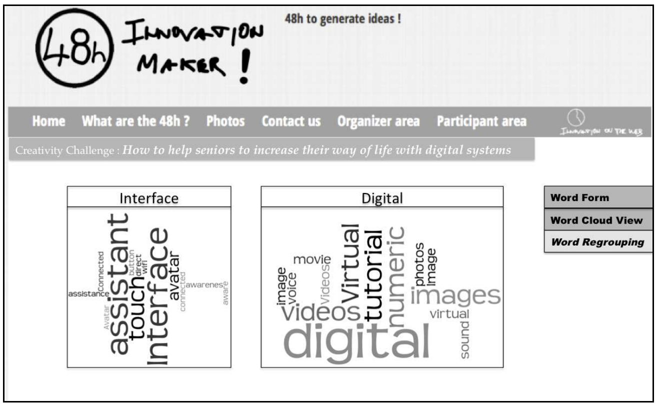

Fig.3 Words Regrouping generated by the system for the subject "How to help seniors to increase their way of life with digital systems".

VI. CONCLUSION & PERSPECTIVES

In this article we have developed a first Natural Language Processing based System that supports the Brain Purge method during the creativity challenge. The system assists the creative participants to highlight the words, which are the most spelled by the creative team, and proposes a regrouping of these words based on the calculus of semantic relationships.

The next step of our work will be to generate a mind mapping system based on the clusters to help the creative participants to identify the main themes emerging from the brain purge method. This first result will allow the system to assist the creative teams during the other creativity methods such as the Reverse thinking, the analogies, the association, etc.), and reuse the themes which have been identified during the brain purge method. We expect that our system will facilitate the creation of new ideas during the creativity challenges.

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