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Innovonto: An Enhanced Crowd Ideation

Platform with Semantic Annotation

Hallway Test

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Abstract

Crowd ideation platforms provide a promising approach for supporting the idea generation process. Research has shown that presenting a set of similar or diverse ideas to users during ideation leads them to come-up with more creative ideas. In this paper, we describe Innovonto, a crowd ideation platform that leverages semantic web technologies and human collaboration to identify similar and diverse ideas in order to enhance the creativity of generated ideas. Therefore, the approach implemented captures first the conceptualization of users' ideas. Then, a matching system is employed to compute similarities between all ideas in near real time. Furthermore, this technical report outlines the results obtained from the evaluation of Innovonto platform. The hallway study, conducted at our research group, allowed us to test each step of Innovonto platform as well as the proposed approach in assessing similarities between ideas. As results, we received 20 ideas and 23 feedbacks from 9 users. The analysis of the results shows good performance of Innovonto steps and confirms the findings of existing research.

Keywords: Collaborative Ideation, Semantic Annotation, Ontology Matching, Brainstorming, Crowd Ideation, Creativity.

1 Introduction

Crowd ideation platforms are designed to support users in generating creative and diverse ideas. Most of these platforms support the "brainstorming technique" due to its remarkable success that has been shown so far[24]. This technique seeks to increase the creativity and number of ideas by encouraging intensive exploration of ideas of others while restricting criticism[2].

Moving brainstorming from a collocated setting to an open online platform yields several benefits: (1) a large number of the crowd allows the generation of a large number of ideas and (2) the heterogeneity of the crowd increases the potential for high quality ideas due to crowd's different background [11]. However, new challenges arise in distributed large-scale ideation platforms, for example, (a) many ideas are basic, mundane and repetitive [9] and (b) due to the number of ideas it's economically unfeasible to sift through all of them in order to filter-out low quality ideas [9].

To increase the creativity[1] of ideas generated, most of research exposes ideas from a large collection of crowd ideas [6] to users during ideation. However, one promising approach regarding the exposure of ideas is to select a set of inspiring ideas systematically. Research has shown three ways of exposing inspiring ideas that help users during the ideation: (1) by showing diverse ideas which allow users to explore different creative paths to provide diverse ideas; (2) by showing similar ideas which allow users to explore one creative path and develop ideas deeply; (3) by building a map that clusters the ideas, which allows users to explore different clusters.

However, a major issue in crowd ideation is "*how to assess similarity between ideas in order to provide similar/diverse inspiring ideas from hundreds*" [8]. Existing

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[1]In our work, we consider the creativity of ideas that responds to the dimensions of novelty, feasibility.

approaches either use automatic machine learning techniques or combine human judgments and machine learning (For more details about existing approaches, we refer the reader to our prior work [4]).

Unlike existing approaches, the Innovonto platform implements an approach based on semantic web technologies in order to select a set of similar/diverse ideas systematically. The proposed solution consists of two main steps: (1) capturing the conceptualization of users' ideas and (2) employing a matching mechanism to calculate similarities between ideas in near real-time. The first step is performed by annotating concepts (see section 2.2) in the idea description text submitted by the user [2]. The correct conceptualization is interactively corrected by the user: When a concept has different meanings an image of each entity with a short description is shown to the ideator. The ideators then select the image for the concept they think best reflects their idea (i.e. disambiguation of the meaning). For instance, the concept "window" could correspond as an architectural structure or window as a widget - as a graphical user interface element; in this case, the user selects which one corresponds to his concept by selecting the image. The second step is performed by employing structural, terminological and linguistic matchers to calculate similarities between all ideas.

The rest of the paper is organized as follows: Section 2 provides a detailed description of the Innovonto platform. Section 3 describes the methodology. Section 4 presents the results obtained from the conducted study. Sections 5 and 6 summarize our contributions and outline future work.

2   The INNOVONTO Platform

This section describes in detail the main steps of the Innovonto platform. The Figure 1 highlights the steps performed by the user. The step *"see inspiring ideas"* (see Figure 1) is necessary to enhance the creativity of ideas to generate. This step which allows us to obtain inspiring ideas involves another process illustrated in the Figure 5.
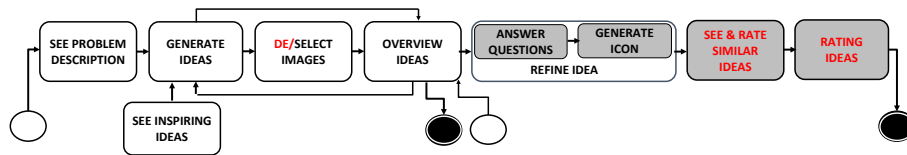

Figure 1: Process of the Innovonto Platform.

Furthermore, research has shown that ideators spend a limited amount of time within the ideation process [8], therefore, we made some steps of the Innovonto platform optional (steps colored in gray of the Figure 1) where the ideators can skip them anytime. The purpose of making some steps optional is to avoid distracting

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[2]Semantic annotation is the process of enriching and representing information with semantics [13].

users from generating ideas. Moreover, the steps "See and Rate Similar Ideas" and "Rating Ideas" (steps of the Figure 1 where the text is colored in red) were not yet implemented in this first iteration of Innovonto Platform. The interface that includes all Innovonto steps (i.e.Home page) is illustrated in Figure 2.
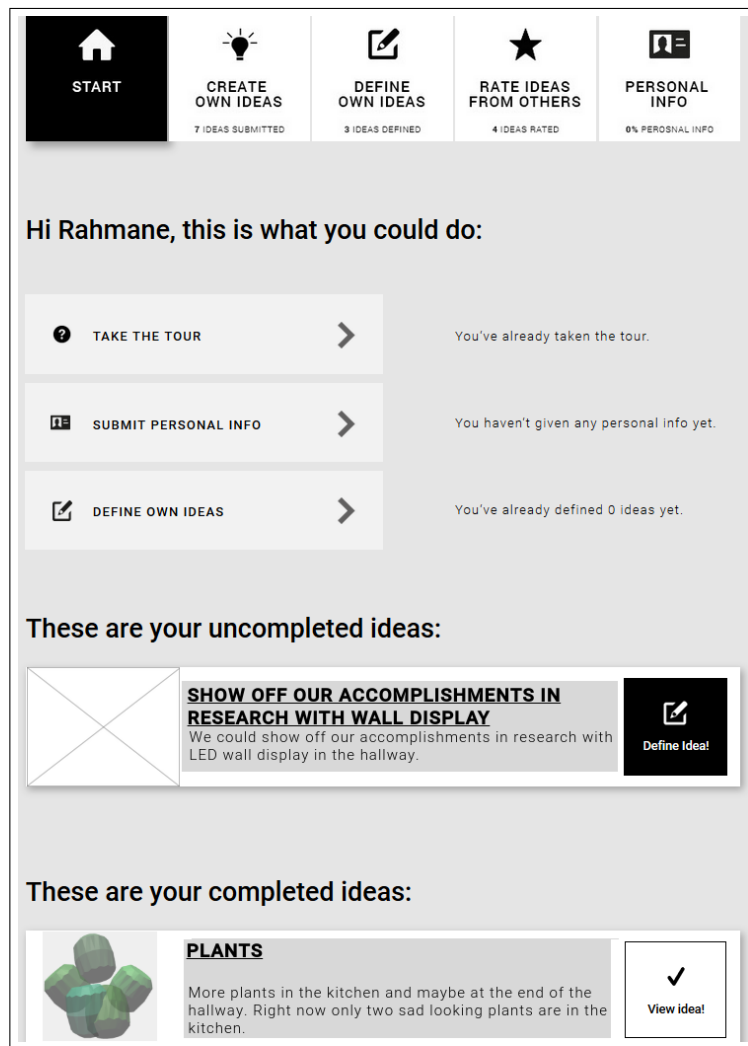

Figure 2: Home Page of the Innovonto Platform

2.1   See Problem and Idea Generation Steps

Most of the existing ideation platforms start with a problem description to generate ideas. Based on existing research, the problem description should be simple,

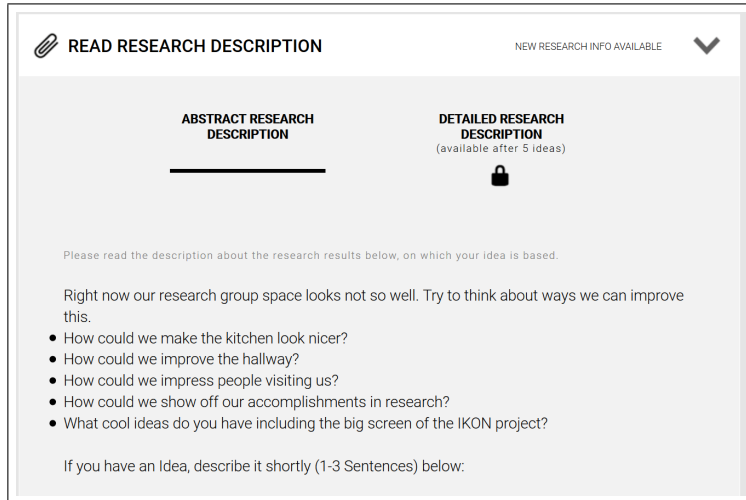described in short text and familiar to ideators.

Figure 3: Problem description interface of Innovonto Platform.

In the first iteration of Innovonto platform, we adapt this strategy, i.e. problem solving and asked users to generate ideas on "how to enhance our workspace" (see Figure 3). We choose this problem, because the users are familiar with their work environment and therefore come up with ideas easily. When the users come-up
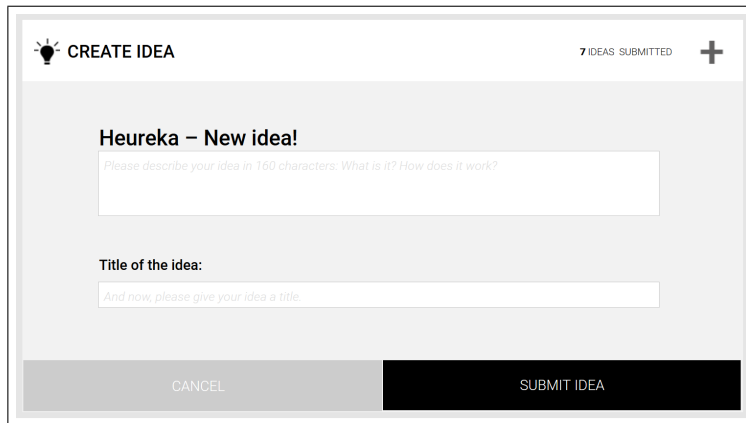

Figure 4: Idea generation interface of Innovonto Platform.

with ideas, they should give a title and a short description (see Figure 4). During the submission, the users are asked to select/de-select images that reflect the concepts of their ideas. The purpose of this mandatory step is explained in the next section.

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2.2 Inspiration and Image Selection Steps

This step is the main contribution of the Innovonto platform since it uses semantic web technologies to enhance creativity of generated ideas. A variety of research has been conducted to enhance the crowd ideation creativity by presenting a set of inspiring ideas. Therefore, the Innovonto platform implements this step as well to help users to get unstuck by showing diverse ideas. The process of this step (from both the user and machine perspective) is illustrated in Figure 5.
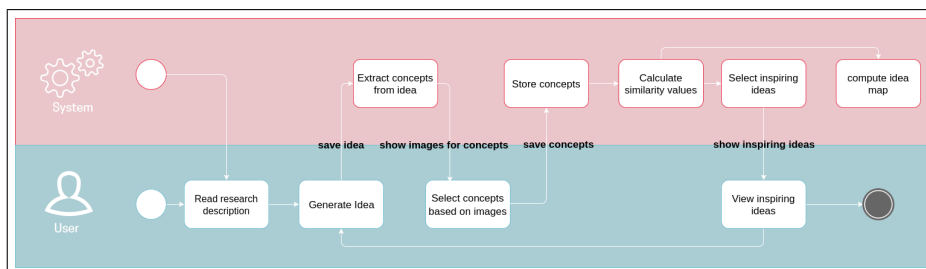

Figure 5: Process of Selecting Idea and Generating the Solution Map.

To get these inspiring ideas, our platform uses semantic web technologies to assess similarity between all generated ideas. The proposed approach[4] mitigates the problems of related work in the assessment of similarity: (1) statistical matching gives inferior results due to conceptual divergence (i.e. using different vocabulary to describe the same meaning), since the ideas are presented in short texts. (2) human-computational approaches are based on human judgments (e.g. asking the crowd to rate the similarity of users' ideas or arrange them) which are considered as tedious, repetitive and require a shared knowledge about ideas.

The proposed approach consists of two main phases: idea annotation matching. These two phases are described as follows:

2.2.1 Idea Annotation Phase

The proposed approach[4] starts first by extracting concepts from the idea description using NLP Stanford API[3]. The NLP Stanford algorithm analyzes the grammatical structure of the idea and identifies nouns, verbs, etc.

Next those concepts (nouns) are linked to entities from an external knowledge base DBpedia[4] and Wikidata[5] using SPARQL query1.

The query received as input the concepts extracted and returns resources found in DBpedia that have the same label as concept names.

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[3]Natural Language Processing `https://nlp.stanford.edu/`
[4]`www.dbpedia.org`
[5]`www.wikidata.org`

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
select ?resource where {
?resource rdfs:label ?concept
}
```
Listing 1: SPARQL Query for Linking Concepts with DBpedia

The main challenge of this step is to annotate concepts with their corresponding information (i.e. adding more information about the extracted concepts). For this end, the image selection step is considered as mandatory in Innovonto platform. To validate the annotation with correct information, the ideator is asked to select a set of images for the extracted concepts that reflects his idea (see figure 6).
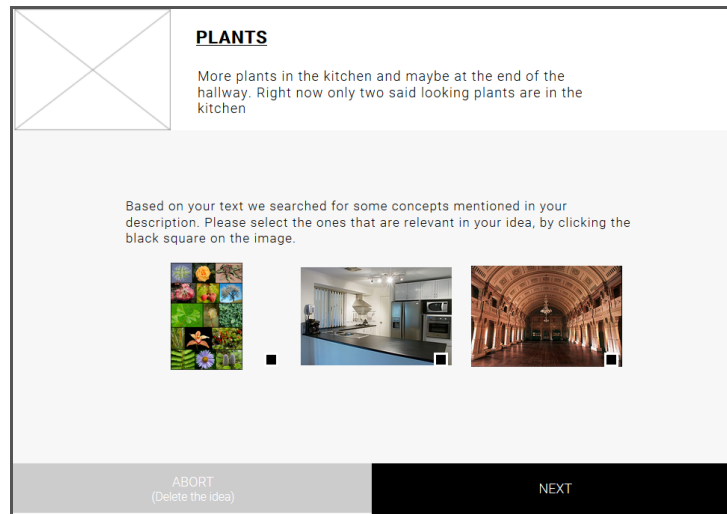

Figure 6: User Interface for the Validation of the Extracted Concepts Phase: Plants Idea.

These images are obtained from the corresponding entities in DBpedia2. The query received as input the concept URI found in DBpedia and returns the description and image (thumbnail).

```
PREFIX dbo: <http://dbpedia.org/ontology/>
select ?thumbnail ?description {
conceptUri dbo:thumbnail ?thumbnail;
            dbo:abstract ?description.
FILTER (langMatches( lang(?description), EN)).
}
```
Listing 2: SPARQL Query for Getting description and image of Concepts from DBpedia

The image selected by the ideator for each concept allow us to store the correct concepts along with their superclasses and additional information (e.g. concept descriptions) using the two following SPARQL queries 3 4. These information are obtained from Wikidata, therefore, the query 3 receive as input the resource found in DBpedia that has been validated by the user and returns the same resource in Wikidata (conceptQ). The second Query 4 returns all superclasses of the resource found in Wikidata.

```
PREFIX dbpedia: <http://dbpedia.org/resource/>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
SELECT ?obj ?label WHERE  {
conceptUri (owl:sameAs|^owl:sameAs) ?obj
FILTER(CONTAINS(str(?obj), "http://www.wikidata.org"))
}
```

Listing 3: SPARQL Query for retrieving the same DBpedia concept from Wikidata

```
PREFIX wdt: <http://www.wikidata.org/prop/direct/>
PREFIX wd: <http://www.wikidata.org/entity/>
SELECT DISTINCT ?item  ?label WHERE {
wd:conceptQ + wdt:P279 + ?item.
}
ORDER BY DESC(?item)
```

Listing 4: SPARQL Query for retrieving superclasses of a concept from wikidata

2.2.2 Matching Ideas Phase

We implemented a matching system to calculate semantic similarities between the concepts that represent the ideas. The matching system implemented uses terminological, structural and linguistic matchers to cover the maximum heterogeneity. These matchers are combined using average strategy (see equation 1). For the terminological matcher, we used string similarity measures, namely the Levenshtein distance (see equation 2) [22]. For linguistic matcher, we have used WordNet as an external dictionary to detect synonymous and antonymous concepts. The approach uses Lin algorithm (see equation 3) [26] on WordNet[6] to compute linguistic similarity. For the structural matcher, the system compares the external structure of concepts (i.e. comparing superclasses) obtained from external knowledge base (DBpedia/Wikidata), more specifically the system uses the upper cotopic similarity (see equation 5), to reduce the conceptual heterogeneity [25].

$$Sim(c, c') = \frac{A+B+C}{3} \tag{1}$$

Where A, B and C formulas are given as follows:

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[6]https://wordnet.princeton.edu

Levenshtein distance   We calculated the similarity value using Levenshtein distance as string-based algorithm. The Levenshtein distance between two strings a,b is given by $lev_{a,b}(|a|,|b|)$ where:

$$lev_{a,b}(i,j) = \begin{cases} max(i,j) & if\, min(i,j) = 0 \\ min \begin{cases} lev_{a,b}(i-1,j)+1 \\ lev_{a,b}(i,j-1)+1 \\ lev_{a,b}(i-1,j-1)+1_{a_i \neq b_j} \end{cases} & otherwise \end{cases} \tag{2}$$

where $1_{a_i \neq b_j}$ is the indicator function equal to 0 when $a_i = b_j$ and equal to 1 otherwise.

Linguistic Matcher   The Lin metric 3 measures the information contents of each term. This measure is applied on a Wordnet dictionary to get the information about the terms. The similarity value IC_{mis}(C1,C2)<IC(C1) and IC(C2) is normalized between 1 (similar concepts) and 0.

$$B = sim_{Lin}(C1,C2) = \frac{2IC_{mis}(C1,C2)}{IC(C1)+IC(C2)} \tag{3}$$

We call concept C the most informative subsumer of two concepts C1 and C2 i.e. IC_{mis} if concept C has the least probability among all shared subsumer between two concepts (thus most informative).

Where IC(C) is calculated as follows:

$$IC(C) = -log\, p(C) = -log\frac{freq(C)}{freq(root)} \tag{4}$$

The intuition behind information content is that, more frequent terms are more general and hence provide less "information": freq(C) is the frequency of concept C, and freq(root) is the frequency of root concept of the ontology. Frequency includes the frequencies of subsumed concepts in an IS-A hierarchy.

Structural Matcher   We computed the structural similarity based on hierarchy of supercalsses obtained from (DBpedia/Wikidata). Therefore, we applied the upper cotopic similarity, which computes the similarity as follows:

Let π: O × O R is a similarity over a hierarchy H = (h ≤ O), such that:

$$C = \pi(c,c') = \frac{|UC(c,H) \bigcap UC(c',H)|}{|UC(c,H) \bigcup UC(c',H)|} \tag{5}$$

Where UC(c, H) = {c' ∈ H; c ≤ c'} is the set of super-classes of c.

Delivering Inspiring Ideas Our platform shows users a set of three diverse ideas by request, i.e. pull inspiration[7]. The most diverse ideas are obtained by selecting the ideas with low similarity value computed by matching system (see figure 7). We choose diverse ideas in order to help ideators to get unstuck by exploring different paths of creativity.
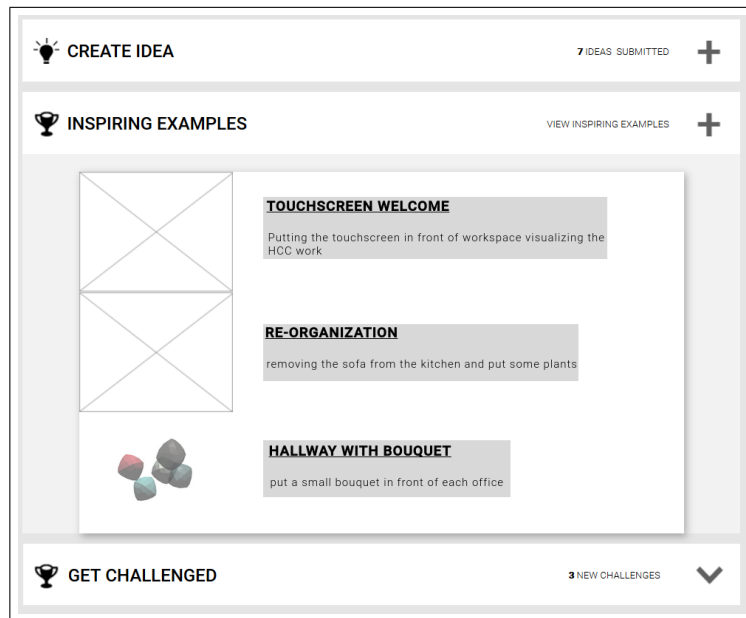

Figure 7: Inspiring Ideas Interface of Innovonto Platform.

Solution Map

To visualize an overview of the similarity between all ideas generated, we used t-distributed stochastic neighbor embedding (tSNE): a *dimensionality reduction algorithm* to place the idea on a 2D surface [8]. The solution map can be used not only to enhance creativity but also to (a) observe which categories have a low number of ideas and (b) facilitating the filtering of ideas for a given category.

2.3 Overview and Refining Ideas Steps

After submitting an idea, three options are available for the ideators (1) leaving the platform, (2) generating more ideas or (3) refining submitted ideas (see figure 8).

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[7] The pull inspiration is supported by the SIAM (Search for Ideas in Associative Memory) model [12] to avoid fixation.

[8]t-SNE is a dimensionality reduction algorithm, that tries to learn a lower dimension placement of data-points by using gradient descent. The objective function is modeled so that it retains local clusterings in the data, in contrast to other dimensionality reduction algorithms like principal component analysis. It is applied to the pairwise similarities of ideas, in order to map them to a 2-dimensional space.

After submitting an idea, the users are redirected to an "idea generation page" where they can then generate more ideas (see figure 1).

Otherwise, they can refine a submitted idea by first getting an overview of all their submitted ideas and then, select which one to refine. The refinement is performed by (a) answering refinement questionnaire (see figure 13) and (b) generating an icon for the idea (see figure 14). The purpose of the refinement step is to get more information about idea, for instance to see if the idea can be feasible or not.

We considered a refinement questionnaire in this first hallway test according to the problem to solve which is "how to improve the HCC workspace". These questions are as follows:

- Who will benefit from this idea?

- Which costs would be needed for your idea (roughly estimated)?

- Which challenges could be overcome with this idea?

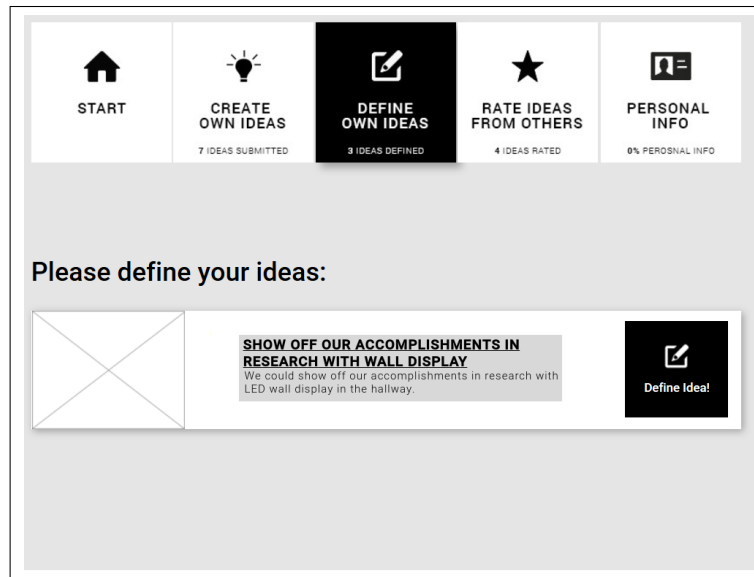- How could the idea be implemented differently?

Figure 8: Define interface of Innovonto Platform (list of not refined ideas).

3   Methodology

We conducted a hallway test to evaluate the platform as well as the proposed solution in obtaining inspiring ideas. As we mentioned before obtaining inspiring ideas

helps crowd ideation platform to enhance the creativity of the ideas. We also examine the effects of the mandatory step of image selection (explained in section 2.2) as well as inspiring ideas during the idea generation process. In the following, we describe the methodology conducted during the hallway test.

3.1 Participants

The participants involved in our experiment study were members of our workgroup, the Human Centered Computing Lab[9] (HCC). We sent emails to all members, asking them to participate in our platform. We had 9 participants (5 male and 4 female).

3.2 Task of Generating Ideas

We let the Innovonto platform open for three days, then, we asked participants to generate ideas on "How to improve the HCC Workgroup Space". The participants deliberately did not receive a tutorial for the platform. The purpose of this was to observe how much difficulties they can encounter during navigating on our platform.

    We gave participants the freedom to choose when to start their idea generation without any time limitation, so not all participants had to generate ideas at the same time. In addition, our idea generation process supports the collaborative aspect by showing inspirational ideas from others. We show users the most diverse ideas (i.e. ideas with low similarity) from the already generated ones. Therefore, each ideator may have seen a different set of inspiring ideas due to a re-calculation of similarities between the generated ideas and the new one, once submitted.

3.3 Process

Once being on the platform (see figure 2), the user could "take a tour" (which an optional step), where different steps of the idea generation process are explained. The next step is to generate ideas, for this end, the user should read the problem (in this case, "how to improve HCC workspace", see figure 3) and then think about some ideas. However, during this step some options are available to help users to get unstuck and get inspired, such as seeing three most diverse ideas of other users (see Figure 7). We should note that seeing inspirational ideas is requested by the user. Another option that we considered to enhance creativity is showing users the most three similar ideas, however, this step was not implemented yet.

    When the users come up with ideas, they should give a title and a short description and then submit them (see Figure 4). During the submission, a set of images appears asking if these images reflect the concepts of their ideas (see Figure 6). The users can then select or de-select the images that reflect or not the concepts of their idea.

    Once the idea is saved, the user can either leave the platform or generate more ideas or refine the submitted ideas (see Figure 8). During the refinement, the user

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can (1) answer questions about the idea such as "Which costs would be needed for your idea (roughly estimated)?" and (2) use a generative icon system to create an icon of their idea (see Figures 13 and 14).

A DEMO presenting different steps of Innovonto platform is available online at `https://photos.app.goo.gl/AJPPBp3qqXqiUwNl2`.

3.4   Measures and Analysis

To evaluate the first impressions about the Innovonto platform, we asked users at the end of the idea generation process to answer a survey based on the work proposed in [5]. The questions relate to the following three aspects of their ideation experience:

1. ***Perception of helpfulness of ideas of others***

   - Q1: On average, the ideas of others that you saw were: Boring(1),Interesting(7)
   - Q2: Seeing ideas of others helped me come up with better ideas: Strongly disagree(1),Strongly agree(7)
   - Q3: Seeing ideas of others helped me come up with more ideas: Strongly disagree(1),Strongly agree(7)
   - Q4: Seeing ideas of others helped me get unstuck: Strongly disagree(1),Strongly agree(7)

2. ***Perception of helpfulness of the system***

   - Q5: The system gave me a sense of what ideas other people were exploring: Strongly disagree(1), Strongly agree(7)
   - Q6: Seeing ideas of others gave me a good sense of the range of possible solutions to this challenge: Strongly disagree(1), Strongly agree(7)

3. ***Mental effort and task difficulty***

   - Q7: How much mental effort (e.g., searching, remembering, thinking, deciding) did the task take? : Low mental effort (1), High mental effort (7)
   - Q8: The Image Extraction Step was: Boring(1), Interesting(7)
   - Q9: How was your performance impression of the Image Extraction Step?: Very Slow(1), Very Fast(7)

The survey includes also two questions to obtain qualitative feedback, these two questions are as follows:

- Q10: In overall how do you evaluate the platform?
- Q11: What would improvements would you suggest?

We used the mean (M) and standard deviation (SD) to evaluate the results obtained from the questions mentioned above.

4 Results

In this section, we present the results obtained from the hallway test as well as the insights in order to enhance our platform in the future.

4.1 Number of submitted ideas

As a result of the idea generation process, we received 20 ideas. As we mentioned before, the refinement step was optional, for this end, 14 ideas were refined. The list of ideas can be found in the appendix (Figure 12.

We generated the solution map form the similarities obtained from the matching system. We observed clusters of ideas that describe the same concepts. This is explained by the fact that the semantic annotation allows to get the meaning of the idea and the matching allows a better assess the similarity between all ideas. In the first iteration of the Innovonto platform, the solution map is only accessible by the administrator.
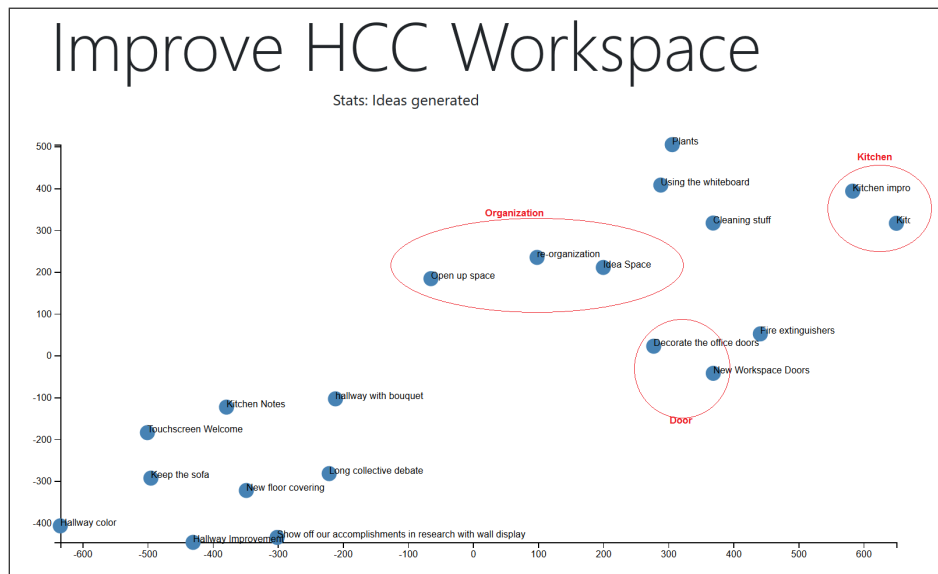

Figure 9: Solution Maps. The maps of ideas generated shows clusters of ideas that share the same concepts. For instance, the cluster labeled "door" means that the ideas of this cluster are about "door". We should note that the clusters have been generated automatically through similarities calculated by matching system, however, the labeling of clusters is done manually.

4.2 Survey Results and Discussion

In the following, we present the results obtained from the survey.

Measures	Questions	M	SD
Perception of helpfulness of ideas of others	- Q1: On average, the ideas of others that you saw were: Boring(1),Interesting(7)	5	1.49
	- Q2: Seeing ideas of others helped me come up with better ideas: Strongly disagree(1),Strongly agree(7)	3.9	2.02
	- Q3: Seeing ideas of others helped me come up with more ideas: Strongly disagree(1),Strongly agree(7)	4.5	1.84
	- Q4: Seeing ideas of others helped me get unstuck: Strongly disagree(1),Strongly agree(7)	4	1.76
Perception of helpfulness of the system	- Q5: The system gave me a sense of what ideas other people were exploring: Strongly disagree(1), Strongly agree(7)	5.2	1.69
	- Q6: Seeing ideas of others gave me a good sense of the range of possible solutions to this challenge: Strongly disagree(1), Strongly agree(7)	3.7	2.16
Mental effort and task difficulty	- Q7: How much mental effort (e.g., searching, remembering, thinking, deciding) did the task take? : Low mental effort (1), High mental effort (7)	3.9	1.52
	- Q8: The Image Extraction Step was: Boring(1), Interesting(7)	4.5	1.27
	- Q9: How was your performance impression of the Image Extraction Step?: Very Slow(1), Very Fast(7)	5.1	1.85

Table 1: List of questions about Innovonto Platform. The table presents the results of the evaluation in terms of mean and standard deviation by asking 10 users participated in ideation using Innonvonto platform.

4.2.1 Participants perceived the system selected ideas of others as similarly helpful

Questions Q1 to Q4 in Table 1 measured the participants' perception of the usefulness of the ideas of others selected by the system. In the survey, the participants found that the users' ideas are interesting (Q1) (see figure 10), the system lead them to come-up with more ideas (Q3) and help them to get unstuck (Q4), which means that the inspiration plays a significant role in the ideation process. However, participants don't find that seeing other ideas helped them to come-up, with better ideas (Q2). This is can be explained by the fact that the problem was easy and the solutions can be easily perceived by most users.
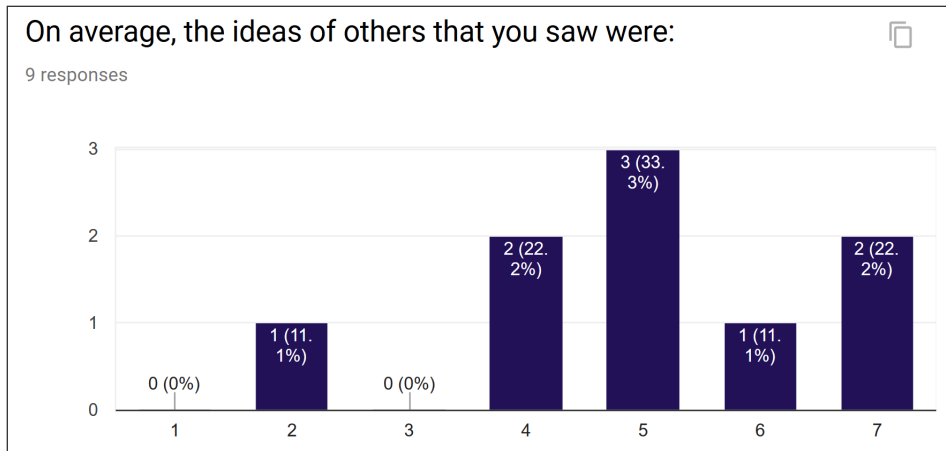

Figure 10: Participants perceived that the ideas of others were interesting.

4.2.2 Participants perceived the system as similarly helpful

Question Q5 to Q6 in Table 1 measured the participants' perception of the usefulness of the ideation system. Most participants found that the system gives them a sense of what ideas other people were exploring (Q5), this is due to the inspiring ideas that they saw during ideation. However, the users see only three diverse ideas, for this end, they do not find that the system gives them a range of possible solutions (Q6).

4.2.3 Participants perceived that the system does not require much mental effort

Question Q7 to Q9 in Table 1 measured the participants' perception of the mental effort required by the system. In this part of the survey, we analyzed our contribution which is the image selection step. The users found that the image selection step interesting (see Figure 11) and fast.
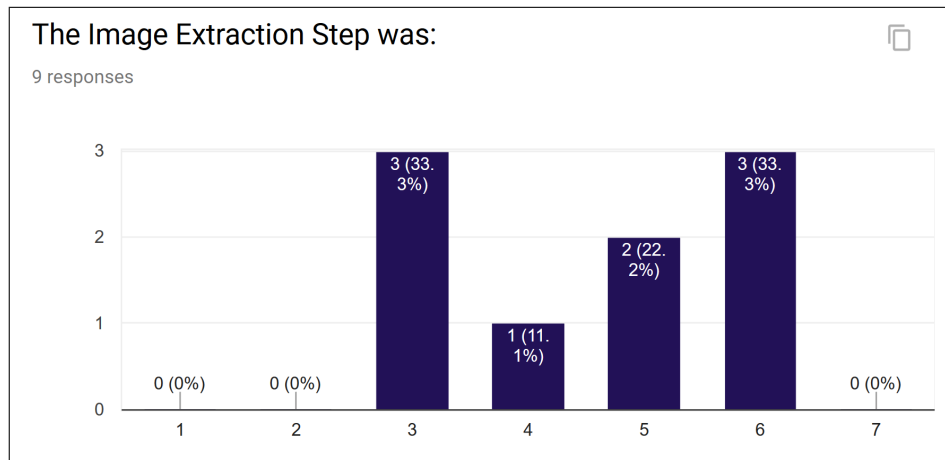
The Image Extraction Step was:

9 responses

Figure 11: Participants perceived that the image selection step was interesting.

4.3 Qualitative Feedback and Discussion

We received 23 fulltext answer for the Questions Q10 and Q11. The full list of feedback can be found in the appendix. To obtain insights about the feedback, we proceed as follows: first we put the different step of our platform as categories, second we classified the comments based on keywords extracted from the comments. This process is achieved manually and the results of this analysis of users' comments led to 6 aspects mentioned below. A short summary of the insights gained for each aspect is given as follows:

1. **Insights about Image Selection Step:** Most participants found the images that reflect the concepts of user idea interesting, however, they suggested that the images should be labeled. In addition, the image selection step needed further explanation in order to be understandable by users.

2. **Insights about Collaboration:** The users want to work collaboratively, not only by seeing users' ideas, but by commenting and rating the ideas. The rating option is considered by our process, but it was not available during the test. However, we didn't consider the commenting on ideas in order to avoid criticism. A study regarding this could be considered in the future in order to see if commenting should be included in the process or not.

3. **Insights about Refinement: Creating an Icon for an Idea:** Most participants like the icon-generator step, however, they found this step difficult and took time and they suggested to be supported by the images extracted during the idea submission and make the icon-generator more easy.

4. **Insights about our Ideation Process:** We should note that users were not willing to refine their ideas which affirm the fact that the ideators don't spend much time in ideation.

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5. ***Insights about the Design of the Website:*** The participants suggested that our platform needs further development from the design part such as adding animation, social features and colors.

5   Discussion

Our preliminary study shows that exposing diverse ideas is helpful for users during the idea generation process which confirms the findings of existing research. Therefore, it is necessary to assess similarity between ideas in order to select set of diverse ideas. To this end, the proposed approach uses semantic web technologies to annotate users' ideas and compute similarities using matching mechanism. However, our solution introduces a new step in ideation process which is the image selection.

The preliminary evaluation shows that the participants found this step interesting and not as a tedious task. Furthermore, the survey shows that this step does not require a mental effort.

In the first evaluation of Innovonto platform, we have only studied the effect of showing the users a set of the most diverse ideas using our approach. We assumed based on previous work that showing most diverse set ideas allows ideators to come-up with more diverse ideas. However, we still need to compare our output in terms of diversity and creativity aspects with the traditional approaches (i.e. asking users to assess similarity).

The hallway study allowed us to receive initial feedback about our proposed solution, however, it is subject to some limitations. First, the study is not representative of the target user group since, participants have a background as computer scientists and a general idea about the Innovonto project. Second the number of participants and generated ideas was low. Therefore, it is absolutely necessary to conduct further study regarding the idea generation process as well as the usability aspect.

6   Conclusion and Perspectives

The Innovonto platform aims to support users in generating creative and diverse ideas. To achieve this goal, the Innovonto platform shows users a set of diverse ideas of other individuals during the ideation process. However, to obtain a set of diverse ideas, the implemented approach assesses similarity of a set of ideas based on semantic web technologies. It consists of two main parts: (1) concepts annotation and (2) a matching mechanism.

Firstly, the concept annotation is performed by concept identification, then search and linking concepts with Wikidata entities and a validation through user-based selection of images are carried out. Secondly, these annotated concepts along with their superclasses are used as a support to calculate the similarity between ideas using ontology-matching techniques. Using our approach, we can assess the similarity of two ideas, which can then be used further to select a set of diverse ideas (low similarity rating) that inspires the user to generate more creative ideas.

We conducted a first hallway test to evaluate our platform Innovonto and the results obtained are so far quite promising. The users found the image selection step which has introduced a new step during ideation as interesting and not as a tedious task, which is a good insight for our solution. Furthermore, we generated the solution map which allows to get clusters of ideas.

We are currently continuing the experimental study by (1) comparing our approach with automatic and human computational approaches (2) conducting a usability test for the image selection, (3) implementing the remain steps "See Similar Ideas" and "Rating". Furthermore, one of Innovonto platform is to generate creative and diverse ideas from one perspective a new technology description instead of a problem-solving. In addition to showing users similar and divers ideas to enhance creativity of ideas, we attempt to explore other ways of collaboration such as showing users a map of ideas (solution map) that obtained from the similarities calculated by the matching system.

Acknowledgements

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7 Appendix

This section presents all ideas as well as the feedback that have been generated during the hallway test.

7.1 Ideas

The list of all submitted ideas are illustrated in the figure 12.

7.2 Feedback

All the feedback obtained from the users are listed as follows:

1. *Image Selection Step (5 comments)*

   - No idea why I was asked to click on the pictures in the process - the pictures did not show up anywhere else.
   - The image extraction was too general.
   - Make sure that at least one image is found - my first idea did not come up with pictures and I could not proceed.
   - de-select the images should be made more clear or just let the images be de-selected by default and let the people select the fitting images...
   - The clarity of the extracted images is a little bit weak, i suggest to annotate images by some short explanation.
   - The Image Extraction Step didn't worked on my pc (macOS Sierra)/browser (Safari). So that would be nice if that would work the next time.

2. *Collaboration (4 comments)*

   - Otherwise it would be nice to have the chance to discuss about ideas and to get in touch with the other ideas makers.
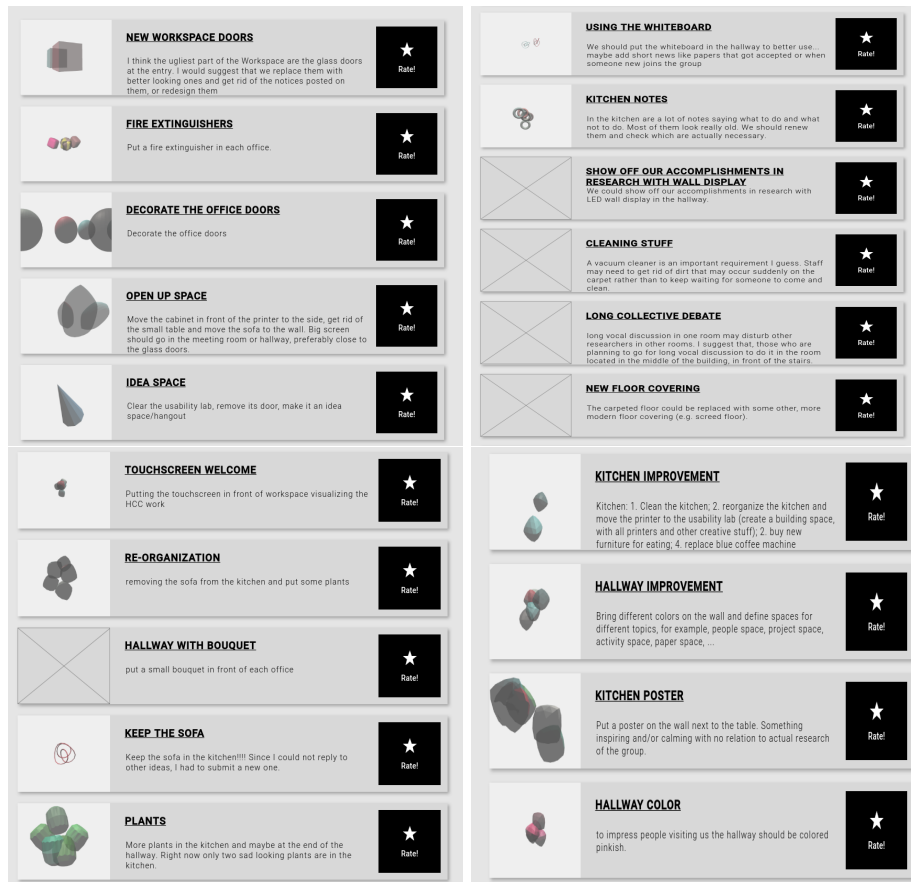
Figure 12: List of Ideas for Improving HCC Workspace.

- Also commenting other ideas and viewing them completely is important but I guess that will be possible in the future?!
- Rating the ideas did not work, would have loved to...
- I was not aware of other peoples ideas while I was writing my first one.

3. **Refinement : creating a icon for an idea (6 comments)**

- Fiddling with the icon took too long - I could not make it change the way I wanted.
- The icon-generating process seems overly abstract and requires many steps.
- Why icon-generating can't this be supplemented by concept extraction as well?
- Take one of the pictures as icon?

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- improve tool for ikon creation. it is too difficult to understand how it works. took too much time, otherwise could be fun.

4. ***Process (5 comments)***

- pictures of other work spaces would be more helpful in challenge.
- Creating ideas was really easy and fast, but defining them took a bit more time and I was a bit lazy with that in the end.
- Can others already see my generated ideas even when I haven't defined them yet? Because I can imagine that some just want to put an idea out there without defining it yet.
- Information should be given whether my ideas will be presented to the other participants personalized or anonymously.
- The ordering of the process is not suitable.

5. ***Design of the website (4 comments)***

- doppelte Elemente reduzieren, Platz besser ausnutzen, Begriffe erklären (define vs. create), unter create your own idea, Textfields auf den Buttons sind nicht klickbar (create idea "7 ideas submitted" +)...
- I think this should be an immediate view. Overall, the website design could profit from more animation.
- Add social features.
- It looks good for personal idea generating but visiting the ideas of the others were too late in the process. Thus, I would rather see it as platform for personal idea generation.

Figure 13: Questionnaire interface of Innovonto Platform (first part of refinement step).
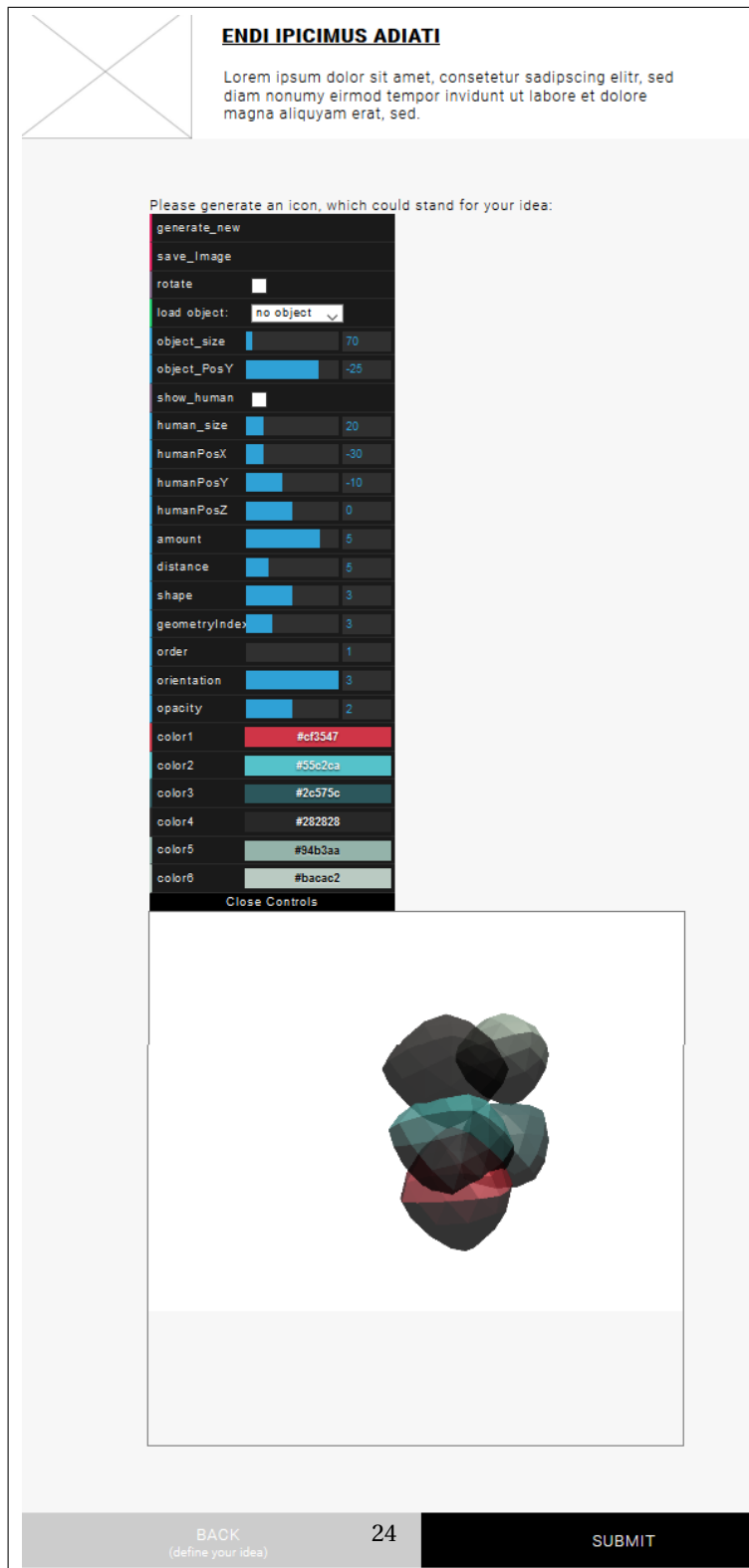
Figure 14: Icon generative interface of Innovonto Platform (second part of refinement step).