Social Networks Gamification for Sustainability Recommendation Systems

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Abstract. Intelligent environments and ambient intelligence provide means to monitor physical environments and to learn from users, generating data to be used to promote sustainability. Communities of intelligent environments offer different answers and behaviors which can be computed and ranked. Such rankings are bound to be dynamic as users and environments exchange interactions on a daily basis. This work aims to use knowledge from communities of intelligent environments to their own benefit. The approach presented in this work uses information from each environment, ranking them according to their sustainability assessment. Recommendations are then computed using similarity and clustering functions ranking users and environments, updating their previous records and launching new recommendations in the process.

Keywords. Sustainability, Ambient Intelligence, Reasoning, Gamification, Social Networks

1 Introduction

Sustainability is a multi-disciplinary area based in fields such as economy, environment and sociology. These fields of research are interconnected, but humans have different psychological approaches to them. Thus, is necessary to perceive the behaviors behind each multi-disciplinary area. A computational platform to support and promote a sustainable environment, together with an approach to the energetic and economic problems, must take the decisions as smoothly as possible so as not to cause discomfort to the user. This topic triggered several psychological researches [1], [2] and a common conclusion indicates that humans are not always conscious about their behavior [3]. This field, called psychology of sustainable behavior, despite focusing on measurement and understanding the causes of unsustainable behavior it also tries to guide and supply clues to behavior change. Manning, shows some aspects that are necessary to consider promoting and instilling in people sustainable behaviors [4]:

- All behavior is situational, i.e., when the situation or event changes, the behavior changes, even if exists intention to perform a certain behavior, circumstances can make it change;
- There is no unique solution, i.e, people are all different because they have different personalities, living in a specific culture, with distinct individual history;

- Fewer barriers leads to a great effect, i.e., when a person is facing social, physical and psychological obstacles, his attitude tends to flinch, for instance, the lack of knowledge about a procedure leads to a retreat;
- There is no single approach to make an action attempting achievement of sustainability, there are many sustainable possible options that a person can choose.

To overcome these barriers to sustainability is suggested that engage multiple users in a competitive environment of positive behaviors so that participants have the need to strengthen their knowledge of sustainable actions and have also the need to overcome social barriers, psychological and physical involving them in a single culture with the aim of changing behavior in various situations and sharing their experiences.

1.1 Game Design

In order to achieve energy efficiency and sustainability users might need to change their behavior and their environment. There are already many studies in this regard, where people use IT to change the behavior of the systems in order to make them more efficient and consume less [5]. Still, there is a common trait among all these studies that most of them act upon the system and not the user. Changing the former is determining what should be its behavior, while changing the latter means changing their habits, the behaviors that they acquired. In order to tackle this problem, two main concepts will be put in practice: Gamification and Information Diffusion.

In [7], gamification is applied in education where the authors try to take the elements from the games that lead to the engagement and apply them inside the school to the students to keep them motivated. Another example uses a framework that allows users to share their daily actions and tips, review and explore others people actions, and compete with them for the top rank by playing games and puzzles [8]. On another example authors developed a service-oriented and event-oriented architecture framework where all participants communicate via events over a message broker. This system is composed by a set of game rules that define game elements like immediate feedback, rank/levels, time pressure, team building, virtual goods and points (karma points, experience points). Completing game rule generates a reward event for the user over the message broker. There is also an analytical component that may be used to analyze user behavior in order to improve game rules and optimize long-term engagement [9].

As for the second concept, Information Diffusion, this will be applied specifically to social networks. What various studies have proven [10] [11] [12] is that social networks have the potential to diffuse information at a high rate. Besides this point, they can also influence other peers to participate by sharing content. The use of social networks, also mentioned above, has the goal of enhancing the engagement of the users to higher levels by bringing the results to public (respecting user's authorizations) and making each user responsible for his actions at the eyes of the respective network.

As we can see through the examples presented, the application of gamification can raise the levels of loyalty of the users and keep them engaged in our objective by making it more enjoyable.

1.2 Sustainability Indicators

Sustainability is a multidisciplinary concept related with the ability to maintain support and endure something at a certain rate or level. The United Nations have defined this concept as meeting the needs of the present without compromising future generation to meet their own needs.

Due to the importance of sustainability different author have defined measures to assess and characterize sustainability. A popular consensus is based on 3 different indicators used to measure the sustainability of a given environment [13]. This approach is based on three different types of indicators, social, economic and environmental with the specific restriction that until all those values are met a system cannot be deemed sustainable. From this perspective sustainability concerns a delicate equilibrium between different indicators which action to optimize one indicator might severely affect one of the other two.

The presence of indicators to assess sustainability is an established practice, however it does not give any information on how to guarantee or plan sustainability. In reality indicator only inform about the current status of a system. This work focuses on using sustainable indicators in order to not only assess sustainability but also provide plans to eliminate bad practices from an environment making it sustainable.

2 Studies on Sustainability Assessment

2.1 People Help Energy Savings and Sustainability (PHESS)

PHESS concerns a multi-agent platform (figure 1) developed to perform sustainability assessment on both users and environments. The platform establishes an ambient sensorization routine upon the environment, constantly updating sustainability indicators. The use of sustainability indicators represents the current, real time assessment of the environment taking into account historic data. The aim of the platform is not only to assess and identify unsustainable practices but also act with the objective of improving sustainability indicators. For such to happen, user behavior and environment might need to be changed. However, how the change is conducted cannot be determined by sustainability indicators alone.

The data gathering level in the PHESS platform includes sensing agents responsible for controlling the access and delivery of ambient sensor data model and reason agents in the reason context level. Model agents are responsible to monitor changes in the environment creating models with patterns common pattern and predictors for sensor value. Moreover, model agents may also be responsible for maintaining user or environment sustainable indicators updated. Reason agents use context information to formulate hypothesis in order to create recommendation, optimize environments and behaviors. This knowledge inferred from agents is then used in acting agents in the Acting level in this platform.

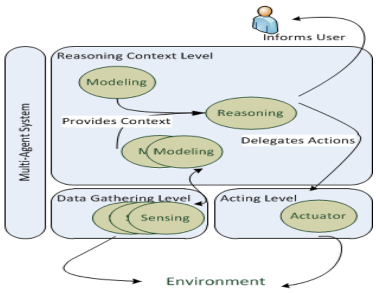

Fig. 1. Multi-Agent System for Deliberation and Sustainable Assurance

In this paper, the process of using indicators from different environments to create and promote recommendation that can be explained is detailed in next sections. An initial explanation about the sustainable indicators and sustainable assessment is necessary to understand the process of creating recommendations. Afterword, the recommendation algorithm is detailed.

2.2 Sustainability Assessment

The sustainable assessment used in PHESS, uses different indicators within each dimension of the sustainability definition. This approach was also used by some authors, which used these indicators to guide strategic options and perform decisions based on the foreseeable impact of such measures [14], [15]. These indicators represent a ratio between a positive and negative contribution to sustainability and their values are computed in the -1 to 1 range. As a consequence, all indicators use the same units of calculation and can be aggregated within each dimension through the use of weighted averages. The use of these indicators is made within each division in the environment and aggregated through average in the environment. The indicators are then categorized according to each sustainable subcategory as displayed in table 1.

Table 1. Sustainability Indicators

		Sustainability Indicators		
		Economic	Environmental	Social
Sample Indicator	Positive	Budget	Emissions Avoided	Time Inside
	Negative	Cost	Emissions	Time Outside

In order to deliberate about sustainability performance it is needed to rank solutions rewarding each solution with a sustainable score, equation 1. This score can them be used to assess and compare environment inside communities helping users improve their scores by sharing good behaviors across a social platform which promotes as examples the best scoring solutions to users so they can improve their score.

$$S_{index} = \alpha * I_{economic} + \beta * I_{enverinmental} + \gamma * I_{social}$$
$$\alpha + \beta + \gamma = 1 \wedge 0 < \alpha < 1 \wedge 0 < \beta < 1 \wedge 0 < \gamma < 1 \quad (1)$$

Sustainable ranking is made using equation 1, which averages indicators within each dimension of sustainability according to weights defines in each dimension. Ideally and for the purpose of this work the weights used are equal, nevertheless, they are presented as a mean to enable political discrimination of certain dimensions over the others. The use of ranking formulas enables the use of fitness functions and distance function to help calculate distances from one sustainable solution to another.

3 Case Based Reasoning to Promote Sustainability

The work here detailed is intended to help communities of users promote practices from environments with high sustainability indexes to other with a recommendation engine. In order to summarize each environment, it was designed a sustainability profile, stating environment and individual room sustainability. Environment indicators are calculated from the use of aggregated individual room indicators, taking advantage of the indicator structure detailed before. Each case is maintained in a profile database and updates using the PHESS multi-agent platform which includes an ambient sensorization framework.

The case based reasoning used in this situation uses a two-step process to evaluate and calculate new solutions for the user. As an initial step, the type of environment is contextualized, for instance, sustainable index, number of divisions and room indicators. A second step concerns the recommendation phase, and uses room indicators to obtain the best solution for the planning of energy use and appliance substitution.

The action flow is detailed in figure 2, where from an initial set of grouped environments a target environment can be compared to environments in higher ranked groups. The initial grouping of environments is made using K-means algorithm on the sustainable index of each environment with a fixed size for number of groups. The retrieval of comparative cases is extracted with the help of similarity functions. In this case, similarity is computed using environments from higher ranked groups and an average Euclidean distance from the distance value, computed for the three sustainability indicators, in every room. This procedure is used taking in consideration the room type, as distances are only calculated for rooms of the same type. The selection of environments favors the longest similarity distance for the value of the indicators in order to help the impact of possible recommendations in the environment. Finally, the list of alternative recommendations is obtained, comparing the room types of the target environment to rooms of the same type in the selecting environment. Any differences found are matched as possible change scenarios, favoring the options taken in the selected environment.

It is useful to remember that sustainable indicators are calculated from data acquired from each environment on a timely basis. The natural consequence is that as time progresses the values of these indicators which might result in environments exchanging the group they were previously.

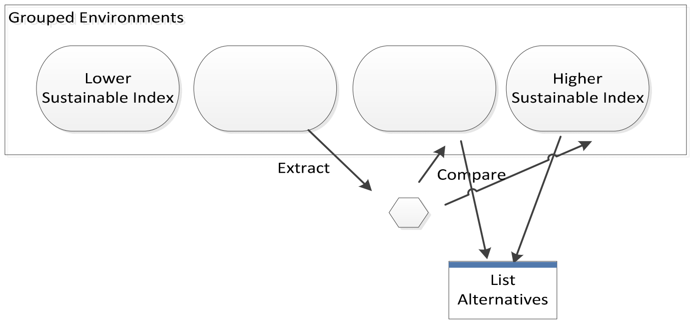

Fig. 2. User suggestion from social database

This dynamic works for the benefit of the system as the selected cases for comparison within each group are changed each time these variations occur enticing environments users to adopt behaviors that do not lead their environment to move to lower ranked groups.

3.1 Results

The results provided in this paper consider an implementation of different intelligent systems inside a community of users. For this purpose and due to current lacking infrastructures and users the environments were simulated defining different environments with different configurations generating user behavior inside them and creating sustainable index using the PHESS platform on such environments.
In order to test the recommendation system within communities, a set of environments was simulated. The setup recreated typical environments commonly found, such as apartments with a bedroom, living-room, kitchen, bathroom and a hall connecting all the other rooms. Inside each room, a set of appliances was also defined ranging from lights and computers to ovens and refrigerators with different consumption patterns. The consumption of appliances was defined from their active use and explicit turn on/off actions from user action simulated in the environment.
In this test 3 environments were defined and divided across 3 groups using the algorithm detailed in section 2.3. The initial step requires information about each environment, namely sustainable indexes for each environment and sustainable indicators for each room inside each environment. This was accomplished running each environment with sample users with sample routines inside each environment in the PHESS system. With information about sustainability on each environment groups was generated resulting with the first group concentrating two of four environments, and one for each of the remaining two groups. Focusing on one of the environment on group with poorer sustainable index, a comparison was made using the environment on the middle group in terms of sustainable index value. For each room possible changes were computed generating a report as defined in table 2 for the living room.
A total of six recommendations were proposed on the target environment in the living room, as seen on table 2, in the kitchen and in the bedroom areas.

Table 2. Example of Recommendations for Living Room

Living Room			
Appliance	Target Room (Average Consumption)	Best Case (Average Consumption)	Decision
Lights	120W	65W	Change
Computer	49W	55W	Remain
Television	60W	30W	Change
TV Box	55W	-	-

Using the PHESS system it was possible to assess that using recommendations on the living room alone was sufficient to improve the target environment sustainability index. In fact, iterating the recommendation algorithm one more time it can be found that if recommendations are followed and user behavior remains equal, the environment would be selected for the middle group, thus showing improvement.

3.2 Discussion

Recommendation calculated can be interpreted as using knowledge created within a community to its benefit. The best cases are used as examples to lower ranked cases which provide sense of sympathy from one to another. Also, with this approach, it is not necessary to maintain a database of efficient objects like appliances or lightning. As soon as they appear in the community they may tend to be selected for recommendation as part of someone's environment definition.

In order to further promote the adoption of recommendations and foster better behaviors, a social game could be devised using a points system where an environment has a default number of points due to the group it is fitted complemented with more points as recommendations purposed by the system were followed. It is believed that the devised algorithm for sustainability recommendation should work on gamification platform providing dynamic objectives and goals which are partial dependent on the acceptance of recommendations updated for every environment on a timely basis.

4 Conclusion

With the proliferation of social networks, users share significant amounts of information. Taking advantage of the number of users inside a community to develop a recommendation engine that promotes sustainability as global objective is the objective of the work here presented. The algorithm results and theoretical background support the idea that it possible to use such strategies to drive a social community of user to optimize itself if recommendations are followed.

Nevertheless, practical validation under real environments and a real user base is still needed to validate simulation results. This should be accomplished using field tests in a community focused on increasing their sustainability.

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5 References

1. D. Bartlett and A. Kane, Going Green : The Psychology of Sustainability in the Workplace Green buildings : Understanding the role of end user behaviour, no. February. 2011.
2. R. Gifford, “Environmental psychology and sustainable development: Expansion, maturation, and challenges,” Journal of Social Issues, vol. 63, no. 1, pp. 199–213, 2007.
3. S. a. Sloman, “The empirical case for two systems of reasoning.,” Psychological Bulletin, vol. 119, no. 1, pp. 3–22, 1996.
4. C. Manning, “The Psychology of Sustainable Behavior,” no. January, 2009.
5. P. K. Gupta and G. Singh, “Energy-Sustainable Framework and Performance Analysis of Power Scheme for Operating Systems: A Tool,” International Journal of Intelligent Systems, vol. 5, 2013.
6. S. Deterding, D. Dixon, R. Khaled, and L. Nacke, “From game design elements to gamefulness: defining gamification,” in Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, 2011, pp. 9–15.
7. J. Simões, R. D. Redondo, and A. F. Vilas, “A social gamification framework for a K-6 learning platform,” Computers in Human Behavior, 2012.
8. [D. Vara, E. Macias, S. Gracia, A. Torrents, and S. Lee, “Meeco: Gamifying ecology through a social networking platform,” in Multimedia and Expo (ICME), 2011 IEEE International Conference on, 2011, pp. 1–6.
9. P. Herzig, M. Ameling, and A. Schill, “A Generic Platform for Enterprise Gamification,” in Software Architecture (WICSA) and European Conference on Software Architecture (ECSA), 2012 Joint Working IEEE/IFIP Conference on, 2012, pp. 219–223.
10. E. Bakshy, I. Rosenn, C. Marlow, and L. Adamic, “The role of social networks in information diffusion,” in Proceedings of the 21st international conference on World Wide Web, 2012, pp. 519–528.
11. A. Goyal, F. Bonchi, and L. V. S. Lakshmanan, “Learning influence probabilities in social networks,” in Proceedings of the third ACM international conference on Web search and data mining, 2010, pp. 241–250.
12. S. A. Myers, C. Zhu, and J. Leskovec, “Information diffusion and external influence in networks,” in Proceedings of the 18th ACM SIGKDD international conference on Knowledge discovery and data mining, 2012, pp. 33–41.
13. V. Todorov and D. Marinova, “Modelling sustainability,” Mathematics and Computers in Simulation, vol. 81, no. 7, pp. 1397–1408, 2011.
14. F. Silva, D. Cuevas, C. Analide, J. Neves, and J. Marques, “Sensorization and Intelligent Systems in Energetic Sustainable Environments,” in Intelligent Distributed Computing VI, 2013, vol. 446, pp. 199–204.
15. N. H. Afgan, M. G. Carvalho, and N. V Hovanov, “Energy system assessment with sustainability indicators,” Energy Policy, vol. 28, no. 9, pp. 603–612, 2000.