Visible Hearts, Visible Hands: A Smart Crowd Donation Platform

Chi-Hsien Yen*
Computer Science
University of Illinois at Urbana-Champaign
cyen4@illinois.edu

Yi-Chieh Lee*
Computer Science
University of Illinois at Urbana-Champaign
be341341@gmail.com

Wai-Tat Fu
Computer Science
University of Illinois at Urbana-Champaign
wfu@illinois.edu

ABSTRACT

On existing crowdfunding platforms, the allocation of money is often not regulated, which leads to less-than-ideal distribution of resources. For example, recent donations to hurricane victims through their crowdfunding campaigns often lead to overfunding of certain victims while underfunding others. Inspired by algorithms from economic theories, we proposed a Smart Crowd Donate system encourages donors to express preferences to multiple projects and reallocates funds dynamically across these preferences over time. We conducted a user study in which recruited 452 participants to simulate a small scale of crowdfunding. The findings of our user study supported the idea that the Smart Crowd Donate system has potential to efficiently distribute funds to projects and allows more projects to receive the amount of money they need.

Author Keywords

Crowdfunding; fundraising; donate; resource allocation;

INTRODUCTION

Crowdfunding sites such as Kickstarter, DonorsChoose, and GiveForward have received considerable attention, as exemplified by the growing numbers of projects and donations on such platforms. The key characteristic of crowdfunding is that anyone can raise money directly from the global "crowd" to help accomplish his or her design projects or various other purposes, bypassing traditional funding sources such as venture capitalists and financial institutions. In addition to raising funds for commercial purposes, crowdfunding websites have also been adopted by philanthropic organizations to attract potential donors and promote specific campaigns [20].

Typically, a crowdfunding project aggregates capital from many donors' small donations. Each donor may have a different perspective on the value of the project, but most intend to maximize the benefit of their donations with limited funds, leading them to give preference to lower-risk projects or donate less than their judged value [23]. This may result in some high-quality projects being unable to reach their donation goals, while a few superstar projects receive several times the amount of donations they were initially seeking [19]. For example, in September 2017, Hurricane Maria hit Puerto Rico and several other countries and caused tremendous damage and financial loss. To recover from the disaster, some organizations and individuals were raising fund through crowdfunding platforms. On current crowdfunding websites [9], we can find there were many on-going related campaigns; however, the funding distribution is inefficient - few campaign were highly overfunded, but many others were still far from their raising goals.

Previous studies [14, 24] have shown that success rates of the projects on crowdfunding websites are often low. While the majority of successful projects receive donations at or slightly above their target amounts, a significant proportion of projects attract funds totaling 200% of their target amount or more [14]. In addition, many projects receive donations only in the first few days after they are launched and thereafter slowly lose the attention of potential funders before eventually failing. These observations led us to speculate that the current "invisible hand" approach of matching massive numbers of small donations to crowdfunding projects is suboptimal, in the sense that the distribution of donations could be improved such that more high-quality projects would succeed.

Solomon et al. [19] demonstrated that superstar projects on crowdfunding websites affect the opportunity for mediocre projects to be funded because the former may set unrealistically high standards for fundable projects in donors' minds. Other studies have shown that social information systems reliant on user dynamics to distribute resources often lead to higher inequality and unpredictability [17], and this may help explain why the distribution of donations to crowdfunding projects is suboptimal. Previous studies [18] have also indicated that crowdfunding will require improved coordination methods, if scarce resources are to be effectively distributed.

In this paper, we present a new system for crowdfunding that renders donations more effective by spreading the benefit across more crowdfunding projects, along with the results of an experiment designed to test how the proposed method may impact crowdfundings complex dynamics. Specifically, the proposed method is inspired by economic theory's deferred acceptance algorithm [16] (Matching algorithm), which was originally used to help optimally allocate students to their

*The two first authors contributed equally to this work

IUI'18, March 711, 2018, Tokyo, Japan © 2018 Association for Computing Machinery. ACM ISBN 978-1-4503-4945-1/18/03 ...$15.00.
https://doi.org/10.1145/3172944.3172971

preferred high schools, by iteratively matching the students who were rejected in the previous round until most students match a school. This algorithm were also applied to various facets, such as wireless communications [4], social network for the exchange of resources [11], and assigning refugees to landlords [2]. These applications demonstrated the prospect of adopting matching algorithm to solve preference-based resource allocation problems. Therefore, we designed a new algorithm to fit the requirements of the crowdfunding environment, and then conducted an experimental simulation of crowdfunding to address the problems of how to distribute donations effectively.

Crowdfunding websites' current method of matching donors to projects is simply allowing each donor to choose a single project to donate to at a time. However, when donors are interested in multiple crowdfunding projects, it is not immediately clear how best to allocate these individuals limited capital into multiple projects in a way that effectively supports all of them. Our system therefore allows donors to select multiple projects simultaneously and decide the total amount of their donations. Our system then automatically spreads out their funds among their chosen set of projects based on the dynamics of ongoing crowdfunding activities.

In summary, the main contributions of this work are as follows. We propose a new donation system that allows donors to simultaneously support multiple projects in a more monetarily efficient way; and we also show how allocation of funding can be more desirable collectively when donors can express and rank their preferences to multiple projects and the system distributes their donations to multiple projects preferred by multiple donors.

RELATED WORK

Generosity is a long-standing tradition in modern societies. In the U.S.A., total giving to charities in 2015 was $373.25 billion, of which 71% came from individuals [21]. While donors are plentiful, prior research [6] has suggested that more than 15% of charitable giving was directed to poorly run organizations. Donors often have trouble assessing the effectiveness of charities, and sometimes rely on word-of-mouth or other social cues to help them make decisions. Andreoni [3] argued that because the impact of charitable giving cannot be quantified as easily as consumer products can, it is hard to predict behavior of individual donors. A few studies [15, 10] have shown that individual donors are concerned about the impact of their contributions, but in general, the effects of the perceived quality of charitable organizations on donating behavior has received relatively little scholarly attention [3].

Recently, people are choosing to donate to charities through many crowdfunding platforms. For example, GoFundMe aims to help nonprofit projects obtain capital; GiveForward provides a platform for patients to raise money for medical treatment; and DonorsChoose allows schoolteachers to seek funding for improvements in educational quality. These platforms strategies for encouraging potential donors to sponsor crowdfunding projects include donation matching and conditional donation [5], resulting in a wide array of cues that affect donors decision-making. For instance, information on past donors behavior may influence the decisions of future donors.

Research on Crowdfunding

Prior studies [12, 18, 23] have shown that policies regarding how donations can be made, how they are allocated, and how donors are rewarded will have significant impacts on the general process of matching donations with projects [12]. In general, these studies found that donors strive to maximize the impact of their donations, either to magnify the potential rewards to themselves (e.g., products they receive), or to promote greater community benefits (e.g., by helping more charitable projects succeed). However, relatively few researchers have studied the effects of new crowdfunding mechanisms [5]. Some of these mechanisms allow backers to provide more information about their project preferences. For example, Beltran et al. [5] proposed a mechanism called conditional donation, in which donors can specify conditions for their donations, and found that this encouraged more donations. Taken as a whole, results from such studies imply that giving potential donors more freedom to express their project preferences is desirable.

A number of studies have identified predictors of success for crowdfunding [24]. While many of these factors favor high-quality projects, others [12, 18] have shown that donation dynamics also greatly impact on the efficacy of crowdfunding campaigns. These dynamics are often not directly related to campaign quality. For example, rapid increases in donations often lead to a snowball effect, leading in turn to a rich-gets-richer effect similar to information cascades [1]. The rate of new donations also tends to increase when project deadlines are close, and when a project nears its target funding goal [1], suggesting that, all else being equal, donors prefer projects that are more likely to succeed. For example, by analyzing data from DonorsChoose, Wash [22] found that the size of the donation made by the last donor to a successful project tended to be much larger than the average donation to the same campaign, presumably because the donor knew his/her money was sufficient to help the project reach its goal. This suggests that donation dynamics and timings may play a significant role in influencing the allocation of donations. Indeed, when unregulated, they may lead to higher inequality and unpredictability of outcomes [17], which may undermine crowdfunding platforms ability to allocate funding to collectively preferred projects.

Charitable crowdfunding websites current method of matching donors to projects is simply to allow each donor to choose a single project to donate to at a time. Previous work [8] indicated that donors are motivated to support crowdfunding projects because of personal beliefs and philanthropic impulses, but worry that their donations will not be used effectively. Hence, how to optimize donors limited budgets in pursuit of more meaningful impacts is emerging as an important issue. When donors are interested in multiple projects, however, it is not immediately clear how best to allocate these individuals limited funds in a way that effectively supports all of them.

Algorithm 1 Donation Distribution Algorithm

```
1:  procedure ALLOCATE
2:      donations_queue ← donations that need to be allocated. (new donation, or donations released from a failed project)
3:
4:      while donation_queue is not empty do
5:          donation ← pop the first donation in donations
6:
7:          // donate to projects that still need funding
8:          project_list ← prioritized projects specified in donation (based on (1) preference (2) deadline (3) money needed)
9:          while donation is not completely allocated do
10:             project ← the next project that is not successful yet from project_list
11:             allocate money to project without overfunding it
12:
13:         // donate to the highest preferred project
14:         if donation is not completely allocated then
15:             project ← the highest preferred project in donation
16:             allocate remaining money to project
17:             released_donations ← same or less amount of donations previously allocated to project that could be reallocated
18:             push released_donations into donations_queue
19:
20:         if donation is not completely allocated then
21:             donation could not be allocated (in this case, all the selected projects in donation are expired)
```

In mathematics and economics science, matching algorithms has been studied to pair agents from two sides of a market based on their preferences. For example, Gale and Shapley (1962) proposed deferred acceptance algorithm (DA) [7], which tentatively matches agents with their highest preferred choices, and iteratively matches the unpaired agents based on their next choices, while allowing already-matched pairs be changed if more preferable pair is found. The algorithm was originally used in school choice systems and stable marriage problems, but recent researchers have adopted it in different fields, such as wireless communications, where channel resources are allocated to multiple users with preferences [4], social cloud, where data storage or computational resources could be exchanged in a social network [11], and immigration issues, like assigning refugees to landlords in Swedan [2].

Although the algorithm could not be directly applied to crowdfunding because the market characteristics are essentially different from economics markets, the ideas of DA inspired us to design a donation allocation algorithm, which allows users to specify preferences over multiple campaigns and distributes donation based on preferences. Our algorithm tentatively allocates money to the user's highest preferred campaign, but defers the final allocation until the campaign is due, thus has the opportunity to reallocate money when better distribution is found. The algorithm is not proved to be stable or has other properties that DA has (which is not our intention in this paper); however, computer simulations were used to show that the algorithm improves overall campaign success rate in various settings [13, 25]. Lee et al. [13] used an agent-based simulation to explore the potential benefits of allowing donors to select multiple projects and distributing their donations by deferring final funding allocation. Yen et al. [25] further investigated this issue by simulating donors' different strategies of selecting crowdfunding projects in order to understand how the donors' behaviors may influence crowdfunding success rate. These works have shown pros and cons of deploying this algorithm by using agent-based simulation; however, it is still unclear how real users may use this new algorithm and how to map this algorithm to a proper interface design. Therefore, we designed an interface that integrates the proposed algorithm and conducted an usability test to evaluate the efficiency and effectiveness of the system through a crowdfunding experiment. In the following, we briefly describe how the algorithm works and how we designed a functioning crowdfunding platform that incorporates this preferential allocating algorithm.

SMART CROWD DONATE (SCD)

We named our algorithm Smart Crowd Donate (SCD). There are two major differences between SCD and current crowdfunding systems.

First, on existing crowdfunding platforms, donors must decide which project and how much money they want to donate without any systematic means of knowing what amount of money would be the most appropriate or helpful in each case. If donors spread their donations too thinly, many or all of the projects may fail because each receives too little money. On the other hand, if donors contribute to just a few projects, those projects may receive more money than they need, while others are starved of funding that they might otherwise have obtained. SCD, in contrast, enables donors to select multiple projects they want to donate to and specify a grand total amount of money that they want to donate to all of them. The system then automatically finds the optimal way to allocate money across the selected projects.

Second, after making a donation to a project on current platforms, a donor cannot reallocate it to one or more other

projects if the first project fails to reach its donation goal, or if it attracts more money than it required. SCD allows all donations to be reallocated to other projects within a certain time period. We expect that by reallocating the money based on the preferences of the donors, our system could help more projects succeed.

In the following, we first describe the most unique feature of the proposed system, the donation distribution algorithm and conducted a user study to investigate how real users interact with our system.

Donation Distribution Algorithm

To realize the above two features, we developed the donation distribution algorithm. Every time a new donation is made or a project fails, the donations previously allocated to that project can be reallocated, and the procedure Allocate (Algorithm 1) is executed to redistribute the pledged money.

For each donation, the algorithm will first consider allocating the money to those projects that are ongoing but not successful yet. When a donor chooses multiple projects for a donation, they are prioritized based on three comparisons, in the order (1) projects with higher preference rankings, (2) projects that are closer to their deadlines, and (3) projects that need the least money. This priority is regard to the following three principles of our system attempt.

1. First, we tend to make the donors be satisfied with the donation distribution, thus, matching the funding to his/her higher preferred projects is essential.

2. Second, increasing the number of successful projects can make more overfunded money could be reallocated to other project. Therefore, if our system helps a project reach donation goal before their project deadline, the higher chance of its spare funding could be redistribute.

3. Finally, the donation continues to be allocated to fill those prioritized projects sequentially until there is no money left. The algorithm will not be overfunded any projects in this step.

Given these prioritization rules, money will be allocated to the lower-ranked projects only when the higher-ranked projects have either succeeded or expired. Otherwise, donors may feel dissatisfied on the grounds that the allocation has not followed their preferences. Also, projects closer to their deadlines are considered higher priority because even if they fail, our system can reallocate the money they were pledged to other projects. Where multiple projects are equally preferred and have the same deadline, the money is distributed to the project that needs less money, because it has a higher chance of succeeding.

If there is still money left after these allocation steps, the algorithm will assign the remaining money to the project with the highest preference ranking even if it is already successful. Then, the algorithm will attempt to move some money other than the donation from that project to other projects (the amount is equal to or less than the donation), because some previous donations may be reallocated. Therefore, more projects can benefit from the reallocated money, while the highest preferred project still succeeds.

In other words, in contrast to current systems, SCD requires that donations be able to move out of projects, as well as into them, in order to optimize overall resource utilization. We therefore set a fixed time period during which each donation may be removed and reallocated to other projects; among other things, this prevents a situation in which the donor never knows conclusively which projects their money has been allocated to.

Donation Methods

In our proposed system, each donor can select multiple projects at the same time, which is called a Multiple Selection (MS) donation. There are three possible different methods to give preferences towards multiple projects, as follows:

1. **MS with multiple Projects (Single-Lv):** In this method, a donor may select up to p projects and decide how much money they would like to donate in total (p is an adjustable parameter in our simulation). The donors do not have to rank their projects, which are all treated by the system as having same preference level.

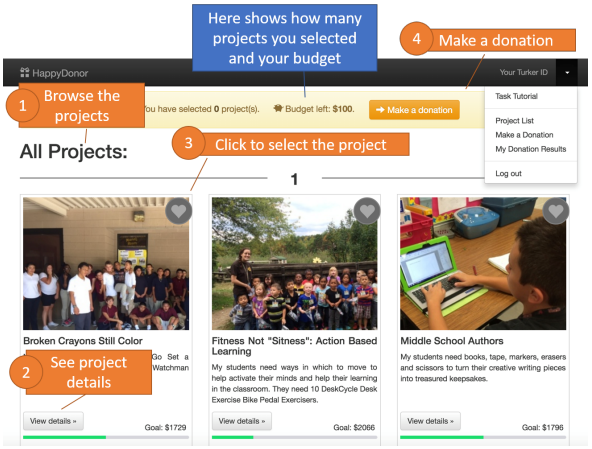
2. **MS with multiple preference Levels (Sequence):** Here, the donor can select up to p projects and determine the amount of his/her total donation, but is required to rank all of their selected projects in a sequence. The system will allocate the money to projects with higher preferences first.

3. **MS with multiple Projects and Levels (Multi-Lv):** This method, we mix the first and second approaches described above. After choosing up to p projects, donors can group their selected projects into different preference levels, within which levels all projects are treated as equally preferred.

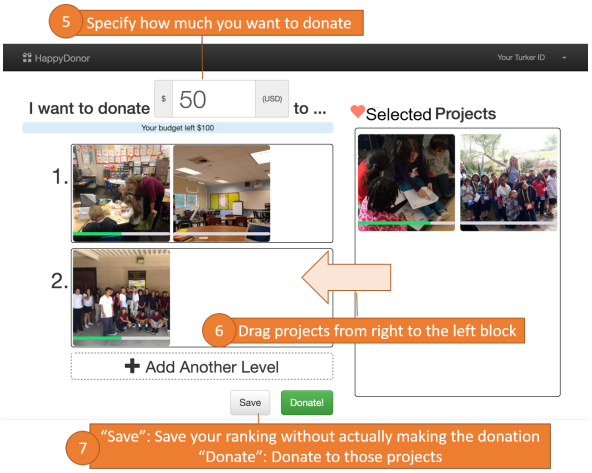
We select these three methods because they reflect the most common types of preferences a person may have towards many choices. When people like many projects but do not prefer any particular one, the preference follows Single-Lv method. When they rank all the projects as how students choose schools, they use Sequence method. Combined Single-Lv and Sequence is the Multi-Lv method. We are interested in understanding how the success rate will change by using different methods, and how people will react when the interface of each is given.

INTERFACE DESIGN

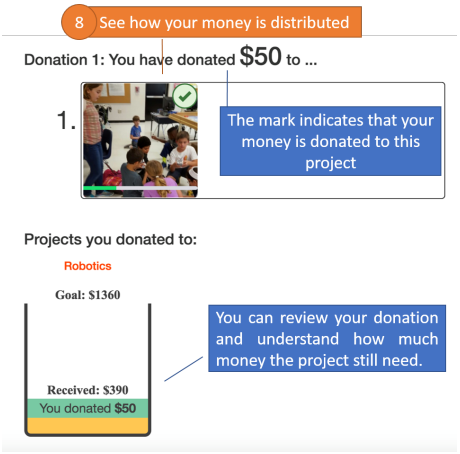
In addition to its novel fund-allocation methods, our system provides a new type of donation interface. Figure 1(a) shows the front page of this interface, which displays current projects on our crowdfunding site, and allows donors to click the heart-shaped icon to select the projects they might want to donate to. The main difference between our interface and those of previous crowdfunding sites is the donation page (Figure 1(b)), the design of which closely reflects the algorithm and three ranking systems described in the previous sections. However, if a donor prefers to donate to just one project, our system allows this. Donors can drag-and-drop



(a) The first page shows ongoing projects on our crowdfunding site



(b) User interface of our donation page on which donors can make a donation for the crowdfunding projects



(c) User interface of our donation page on which donors can make a donation for the crowdfunding projects

Figure 1: This figure presents the interfaces we designed for our donation system. (a)Project list page (b)Donation page (c)Result page

project icons from "Selected Projects (right side)" to "Donation (left side)" and fill in the amount of money they want to donate via the "I want to donate" text box. Depends on the experiment condition a subject was assigned to, he or she can drag multiple projects into the same level (Single-Lv), or add multiple levels (Sequence), or do both (Multi-Lv).

Displaying Donation Results

One of the distinctive characteristics of our donation system is that it defers the final result of donation allocation. Because no other crowdfunding platforms do this, helping donors understand how our system distributes their money is therefore an important issue that may have a major effect on their reliance on our algorithm. Figure 1(c) presents our Donation Results interface. The top of the page shows the list of projects that the donor specified on the Donate page. The use of colorful vs. monochromatic images represents whether a given crowdfunding project is ongoing or failed, and the presence of a mark symbol at upper right indicates whether a donors funds have been distributed to that project.

At the bottom of the Donation Result page (Figure 1(c)), our interface shows the history of the pledged funds movements between a donors selected projects. We use a "cup" visualization to present the funding status of each project. The capacity of the cup denotes the raising goal of a given crowdfunding project; thus, when a new donation is assigned to a project, the liquid level (green part) increases proportionally based on the ratio of the new donation to the raising goal. However, a minimum height for the level of the liquid is assigned for purposes of visual clarity. When the cup has filled up completely, it indicates that the project has received enough money and succeeded.

EVALUATION

To explore the performance of our donation system, we conducted an online user study that simulated a crowdfunding site for educational fundraising campaigns. The study investigated the following questions: (1) How do the donors behave when using different donation methods on our crowdfunding site? (2) Whether does our algorithm distribute the donations to make more projects successful? (3) How satisfied are the donors with our donation system? and (4) How long is a donor willing to wait before learning the final distribution of their donation?

Method

Participants

We conducted this experiment on Amazon Mechanical Turk, with 452 participants (221 females). Their average age was 33 (SD = 10.03), and 49% of them had prior experience of using crowdfunding sites. After completing the experiment, which took between 10 and 20 minutes, each participant was paid US$.6 for their efforts.

Tasks

Project selection. In this study, we focused only on charitable (non-reward) crowdfunding campaigns in order to avoid any bias arising from the nature of the rewards offered a factor that the current version of our donation-distribution algorithm does not yet take into consideration. Therefore, we

selected 32 real crowdfunding projects from DonorsChoose, which helps teachers raise funds for improving educational quality and students learning experience in the classroom. We chose equal numbers of these educational projects from two subject categories, Math & Science and Literacy & Language, to increase the likelihood that a given participant would be genuinely interested in at least some of them. In addition, we chose only projects with donation goals of between US$1,500 and US$2,300, so that the effect of donation goal on selecting projects is reduced when they make donation decisions. We intentionally included a much smaller number of projects in our study than appear on real crowdfunding platforms, because we wanted to encourage the participants to browse most or all of the projects on offer. Most of crowdfunding websites have functions to help sort tons of projects; however, the sorting function may influence donors' donating behaviors, for example, if a donor sorted projects by using deadline, they might tend to donate to the project which is close to the deadline. To ensure that all of the projects had an equal opportunity of being seen and read about, the order in which they appeared on the front page was randomized for each participant.

Project attributes setting. In order to render our crowdfunding site more similar to real-world situations, we controlled the status of each project. First, we divided each of the two thematic categories into four equal groups of four projects each. The first quarter of the projects were initially set as having received 0% of their donation goals; the second quarter, 25%; the third quarter, 50%; and the fourth, 75%.

We set the duration of each project at four weeks, but assigned them different start dates so that some would expire earlier than others. When the study began, a quarter of projects had their full four weeks left to run; a second quarter had three weeks remaining; another quarter, two weeks; and a fourth quarter, only one week to go.

The combination of four initial funding levels and four deadline settings yielded 16 subgroups among the projects, each containing two projects, one from each subject area.

Procedure

Based on the algorithm introduced above, our experiment probed four conditions. Each condition separately includes the same set of crowdfunding projects as described above, but the fundraising progress of the projects in each condition was independent of the other conditions.

Control Condition: This condition was a control group mimicking current crowdfunding sites on which donors only choose one project at a time and decide how much to donate to that project alone.

Single-Lv Condition: The participants assigned to this condition used **Single-Lv** donation method.

Sequence Condition: The participants assigned to this condition used **Sequence** donation method.

Multi-Lv Condition: The participants assigned to this condition used **Multi-Lv** donation method.

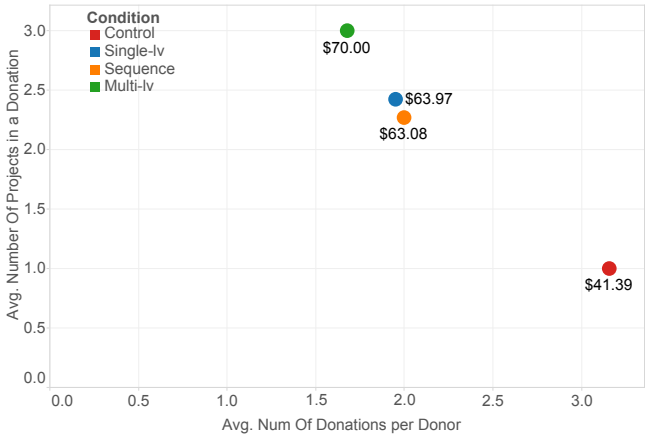


Figure 2: The scatter plot shows the relationship between average number of projects for each donation and average number of donations made by each donor. The labels are the average amounts of money per donation made by each donor.

Each participant was randomly assigned to one of these four conditions, resulting in each condition having approximately 113 participants in it. The experiment ran for 10 days.

Before the participants began to donate via our donation system, we presented them with a tutorial explaining the functions of our crowdfunding site and encouraging them to use it as they would use a crowdfunding site in the real world. Additionally, we informed them that if any crowdfunding project in the experiment successfully achieved its donation goal, we would donate a sum equal to 1% of what the participants had fictively donated to the real campaign [1]. It was hoped that this would encourage the participants to think more carefully about which crowdfunding projects they elected to support.

Each participant in each experimental condition was assigned the same donation budget, of US $100, and was allowed to decide whether to fully expend this budget or not. After they completed the donation process, our system showed them the initial allocation result and informed them that the final result will be revealed in 15 days. Then, we administered an online survey to investigate their decision-making process and preferences regarding our proposed interface and system.

After finishing the donation task, the participants were required to fill in a survey. The survey contained eight items scored using 5-point Likert scales (with 1 = strongly disagree and 5 = strongly agree) and an additional three items consisting of open-ended questions. All 11 items measured users experience with our donation system and their decision-making processes as donors.

RESULTS AND DISCUSSION

Behavior

Figure 2 displays the average number of projects in the four experimental conditions for each donation. Although donors

[1]We did donate money to the original campaigns that succeeded in our study as promised.

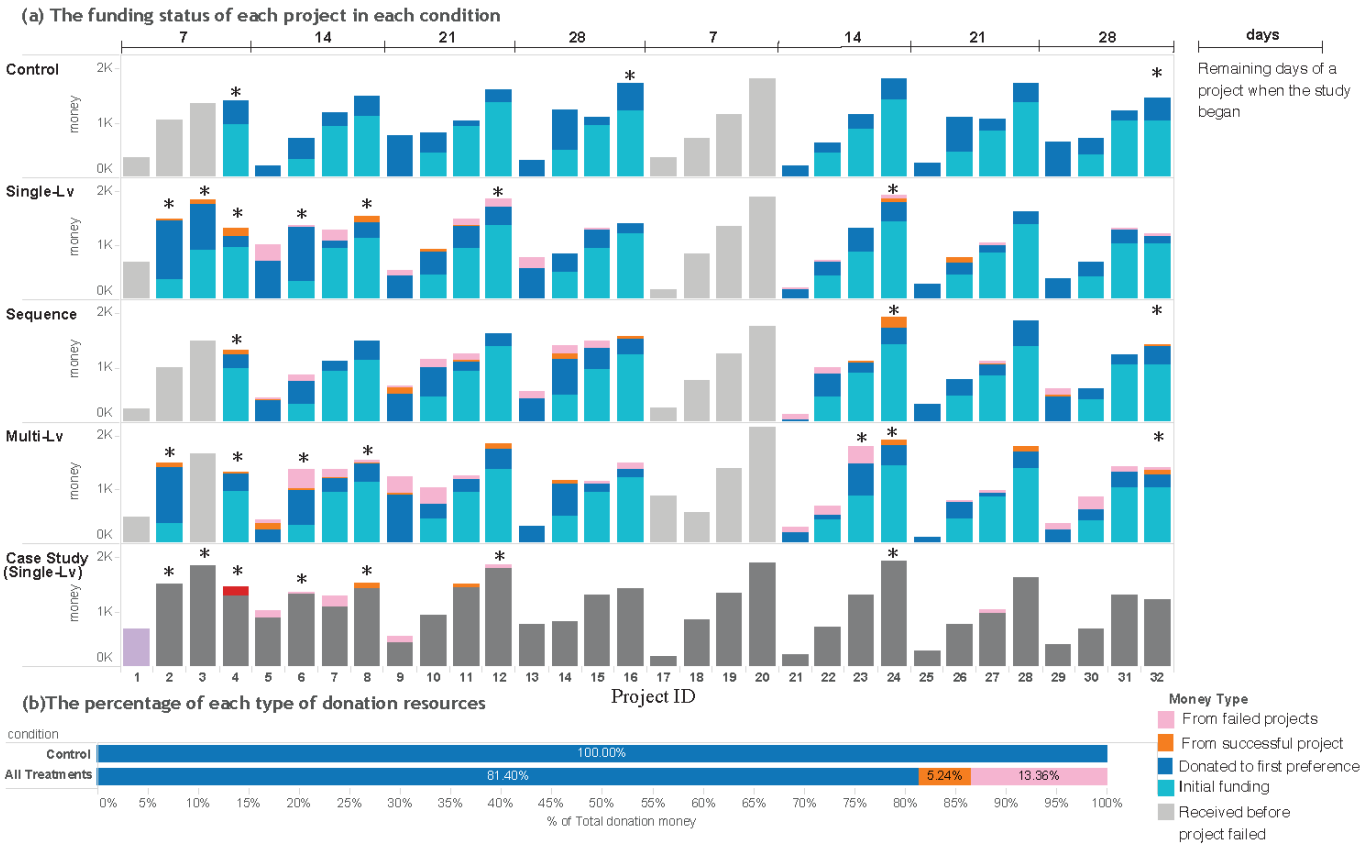


Figure 3: Money allocation among projects. Light blue: initial funding each project had when the study began. Dark blue: money allocated to the highest preferred project. Orange: money moved from successful projects. Pink: money moved from failed projects. Gray: money received by a project before it expired. '*' indicates the project succeeded at the end of the study.

could opt to fund just one project in Single-Lv, Sequence, and Multi-Lv, donors did chose to fund more than one projects in average (1 in Control condition, 2.42 in Single-Lv, 2.27 in Sequence, and 3.00 in Multi-Lv). In addition, as shown in Figure 2, the average number of donations made by each donor in Control condition was 3.16, as compared to 1.95 in Single-Lv, 2.00 in Sequence and 1.68 in Multi-Lv. On the contrary, the average amounts of money per donation made by each donor increase in Single-Lv, Sequence, and Multi-Lv ($41 in Control condition, $64 in Single-Lv, $63 in Sequence, and $70 in Multi-Lv). These findings imply that the donors did show different donation strategies when they utilized our system.

Within the non-control groups, as Figure 2 shows, Multi-Lv had a larger average donation amount than Single-Lv or Sequence, which also caused Multi-Lv's donation times to decrease. In other words, Multi-Lv donors placed multiple projects in the same donation and assigned more money to it. This may have been because donors in Multi-Lv had the most flexibility in arranging the crowdfunding projects they wanted to donate to.

The average number of projects contributed to per donor varied across the four experimental conditions, from as few as 3 (Control condition) to as many as 4.5 (Multi-Lv). This appears to suggest that our donation method encouraged donors to choose more crowdfunding projects. Though the variation was not high (no significant effect), it may have been restricted by the small size of the budgets assigned to the participants. Further research should seek to clarify this result via a larger range of donor budgets.

The more projects the donors chose to donate to, the more flexibility of our system could reallocate the donation. Our empirical user study showed that users generally placed two to three projects in a donation set, even though the interface allowed them to choose more than three. Again, a possible explanation for this may be linked to the small size of the budgets they were given, which may have led them to worry about spreading their limited funds too thinly to have a noticeable positive impact on the projects. Nor did we reveal our hypothesis to the participants that if donors chose more projects, the success rate of the experimental crowdfunding site as a whole would increase. In future research, it might be useful to study the effects on donors behaviors if we were to

explain the potential benefits of our donation algorithm to the users.

Allocation

To show how our algorithm allocated money to increase success rates, Figure 3(a) displays the funding status of each project in each of the four conditions. At the end of our user study, three projects in Control condition, three in Sequence, seven in Single-Lv, and eight in Multi-Lv had succeeded, suggesting that our donation system (Single-Lv, Multi-Lv) might increase the number of successful projects. However, Sequence did not outperform SS. One possible explanation is that the scale of the donations in our user study was relatively small; therefore, less money can be reallocated by using such strict method.

Further investigation of how funds from the participants were distributed among the projects by our algorithm found that, in Single-Lv, Sequence, and Multi-Lv, while the majority of the money (81.4%) was allocated because the project was one of the highest preferred projects in a participants donation, a substantial proportion (13.36%) was reallocated from failed projects, and an additional 5.24% from other successful projects (Figure 3(b)). In other words, approximate 18% of the money in Single-Lv, Sequence, and Multi-Lv were reallocated to other projects for better usage by our algorithm, while this reallocation could not be done in traditional crowdfunding systems (Control condition).

The bottom row in Figure 3(a) provides an example of how our algorithm moved money to help more projects succeed. In condition Single-Lv, project 4 succeeded before its deadline, but kept receiving more money from the donors (shown as a red bar). Because the project had received sufficient support, the algorithm moved the additional funding to other projects that were also preferred by the donors (orange bars). Project 1, meanwhile, failed when its time limit expired. Our algorithm released the money it had received up to that point (purple bar) and moved it to other projects based on the donors preferences (pink). In all, its funds were moved to eight other projects, including projects 6, 8, and 12, which also succeeded in the end.

User Experience with SCD

Overall, the participants reported high levels of satisfaction with our donation system: They found it easy to use the ranking interface (Single-Lv=4.1, Sequence=3.8, and Multi-Lv=3.7). A one-way ANOVA with condition as the independent variable shows significance ($F(2, 340)= 3.3$, $p<.05$), and the post-hoc Tukey HSD test shows that the score of Single-Lv is significantly higher than that of Multi-Lv ($p<.05$). Most also reported that the results page was easy to understand (Control condition=4.34 Single-Lv=4.40, Sequence=4.13, and Multi-Lv=4.2).

We asked the participants who had placed more than one project in a donation (67.35% donors in Single-Lv, Sequence, and Multi-Lv) to explain why they had wanted to selected multiple projects. Most who had done so reported that it was difficult for them to choose between similar projects they wanted to donate to, and that they had therefore selected all of them and allowed the system to help them find the best way to distribute their donations among them. Because the budget was limited, some of the donors who had selected multiple projects reported that it was difficult to decide on a reasonable way of splitting their donations. Two of the participants who selected multiple projects described their experience as follows:

"There was not one project I only wanted to donate to. There were some that were so similar; it seemed wrong to choose just one." (S13)

"I wanted to help all of the choices that I made. The one hundred dollars made me feel limited on the choices I made. I wish I could help them all, there were some excellent creativity and needs." (S101)

The participants who only donated to one project held similar opinions with each other. For example:

"I selected one donation because I really wanted to go all-in on this project. I believe it has the potential to be extremely impactful this teachers students lives." (S43)

As previously mentioned, our SCD donation system announced that it would probably finish redistributing donors funds across the selected projects within 15 days. We asked the participants if they felt comfortable with knowing the final allocation of their donations only after this time had elapsed. Most of the participants reported a positive attitude toward this policy (Single-Lv=3.93, Sequence=3.96, and Multi-Lv=3.81). However, we also asked them how long they would ideally like to wait to know the final allocation results, if they were allowed to decide this.

Half the participants (n=224) reported that ideally, they would like to know the final results of their donation allocation within five days, while the other half (n=228) expressed that they were comfortable with waiting more than five days. It is reasonably clear that if the donation system adopts a longer deferral period, the overall success rate of crowdfunding will increase, and that a deferral period of greater than five days is sufficiently beneficial. The general acceptability to users of a six-day-plus deferral period (i.e., even those who preferred a shorter period did not appear to strongly prefer it) suggests that real-world use of our algorithm is feasible.

In summary, from the results of the user study, we demonstrated that (1) compared to the traditional method (SS), donors did show different donation strategies when they used our system (Single-Lv, Sequence, Multi-Lv), i.e., they chose more projects and assigned more money in a donation. (2) Our algorithm reallocated 18.4% of the money for better usage, and the number of successful projects in Single-Lv and Multi-Lv is higher than the other methods in our study. (3) donors showed positive attitudes toward our donation interfaces and system policies, reflecting the feasibility and practicability of our donation system.

DISCUSSION

Although large amounts of money are donated through crowdfunding platforms every year, success rates of projects

on most such platforms are lower than 60%. Many factors may affect donors motivation to make donations, but we believe one of the main problems is the inefficiency of the current crowdfunding donation method. Because it is difficult for individual donors to assess how much money a project needs at any given time, a better approach is to encourage them to provide their private preferences, and allow the crowdfunding system to adaptively reallocate their donations to those projects that need funding the most. Moreover, from the perspective of project creators, this would allow more attention to be focused on the quality of their projects, and give less weight to funding goals and deadlines than has been the case with traditional crowdfunding platforms [17, 18]. Our study is an initial step in this direction.

Based on our experimental results, in general, donors are willing to trust a donation system to help them coordinate their donations to multiple projects. Although our donation methods allowed donors to put just one project in each donation if they wished, we found that most of them put multiple projects into a donation, which implies (1) that they trusted our donation system to coordinate and optimize their donations, and (2) that it was easy for them to use the system. In the post-study survey, some participants indicated that it was difficult to choose a specific project to donate to, and that they welcomed a way of distributing their donations more widely. This is perhaps especially true of charitable crowdfunding platforms, on which many projects may request comparable materials and/or have similar donation goals.

Moreover, donation methods should aim to provide high levels of freedom for algorithms to reallocate funding, but also high levels of user control, in terms of allowing users to express their preferences. Our results show that different designs of donation interface led to different donation behaviors. The donors made fewer donations, but put more projects and higher amounts of money into each donation, especially as compared to the SS method (Control condition). Multi-Lv provides the highest level of user control, in that they allow the placement of multiple projects in the same level as well as the addition of multiple levels. For these reasons, donors may be able to express their preferences more flexibly. Meanwhile, the more projects are selected in each donation, the more opportunity our system has to reallocate money, which results in more efficient overall distribution.

This method also causes delay of donation distribution. Although our survey result indicated that the participants felt comfortable with waiting 15 days to acquire final donation distribution, we conservatively regard this result. Although a longer delay period helps increase overall success rate as more opportunities of donation reallocation can be exploited, such a long delay time may cause frustration or dissatisfaction among users. Further studies are necessary to understand the delay issue when deploying this system in a real crowdfunding website.

Taken as a whole, the results of the user study indicate the usefulness of our new donation interface, especially for donors who want to make contributions to many projects at a time. This study shows potential pros and cons of deploying the donation distribution algorithm. Compared to the current donation method, SCD encourages donors to select multiple projects in a donation and express their preferences when donating. In addition, the experiment demonstrated how this system could effectively distribute funding to the projects based on donors' preferences. However, few disadvantages of using this method should be considered. For example, donors may take more time to pick up multiple projects and rank them while donating. Also, donors need to wait a certain amount of time to know the final funding allocation. These characteristics of the system might decrease their willingness to donate, preventing impulsive donations. Perhaps in the future crowdfunding site design, donors can choose to use either method in the interface, depending on how they like the way donations are allocated. In any cases, the developers of crowdfunding platforms should seek to strike a careful balance between the flexibility allowed to a donor when expressing preferences, and algorithms' freedom to allocate money.

LIMITATIONS AND FUTURE RESEARCH

This study has some limitations. First, we simulated a crowdfunding site in our experiment rather than applying our system to a genuine site, and only included non-reward, charitable crowdfunding campaigns. Deploying this system to other types of crowdfunding is one of the future research directions.

This kind of fund-reallocation enabled system may not fit reward-based crowdfunding (e.g., Kickstarter) well because donors on those platforms may only be interested in specific rewards. The algorithm should take value of rewards into account when reallocating donations in such scenarios.

Second, we recruited participants from Amazon Mechanical Turk to act as donors. Although this method can attract a variety of participants, it is not capable of simulating the enormous scale of the global audience for real crowdfunding sites. In our study, we assigned a fixed amount of budget to the participants; real donors, making donations with their own money, might have different considerations and reactions/behaviors, which limits the external validity of our study. It would therefore be useful to conduct a study using our system on actual donors. How many projects would a real user select? How would they structure their preferences? Would the reallocating feature affect their motivation to donate, and if so, in what way? In addition, our experiment only included 32 projects so the participants might have chance to review all projects before making decision. However, there are always thousands of projects in a real crowdfunding website, and the donors tend to use ranking and filter functions to help them find preferred projects, which may influence their donation behavior. In other words, it would be worth deploying our donation system on one or more real crowdfunding platforms to verify its benefits in the future.

Lastly, previous studies have indicated that many donors on crowdfunding sites may wait and see how many other donors support certain projects, because they want to choose projects without a high risk of failure [18]. Logically, this could result in a state of mutual hesitation that would harm the success rate of crowdfunding as a whole. It is possible to mitigate this deadline-driven strategies by our system, e.g., showing how

many donors select a project in their donations (not necessarily donate to) to signal the social preference. Future studies should examine this question.

CONCLUSION

Existing crowdfunding platforms generally lack mechanisms for the effective coordination of donations. Our Smart Crowd Donation system allows donors to specify the total amount of money in a donation to multiple crowdfunding projects, which are then allocated the money in an optimal manner. The user study we conducted to evaluate this system found that (1) users could understand the interface well and use it in the intended way; (2) our algorithm could reallocate users money in a manner that caused more projects to succeed; and (3) users had positive attitudes to the overall donation experience, and no strongly negative ones toward the waiting time the system required. This SCD system can be seen as having potential for future use in crowdfunding research and practice to improve resource allocation.

ACKNOWLEDGMENTS

We thank the anonymous reviewers for their insightful comments. This research was supported by grants NSF SES-1419297 and NSF IIS-1441563.

REFERENCES

1. Agrawal, A. K., Catalini, C., and Goldfarb, A. Some simple economics of crowdfunding. Tech. rep., National Bureau of Economic Research, 2013.
2. Andersson, T., and Ehlers, L. Assigning refugees to landlords in sweden: Stable maximum matchings.
3. Andreoni, J. Philanthropy. *Handbook of the economics of giving, altruism and reciprocity 2* (2006), 1201–1269.
4. Bayat, S., Li, Y., Song, L., and Han, Z. Matching theory: Applications in wireless communications. *IEEE Signal Processing Magazine 33*, 6 (2016), 103–122.
5. Beltran, J. F., Siddique, A., Abouzied, A., and Chen, J. Codo: Fundraising with conditional donations. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology (UIST)*, ACM (2015), 213–222.
6. Budak, C., and Rao, J. M. Measuring the efficiency of charitable giving with content analysis and crowdsourcing. In *Tenth International AAAI Conference on Web and Social Media* (2016).
7. Gale, D., and Shapley, L. S. College admissions and the stability of marriage. *The American Mathematical Monthly 69*, 1 (1962), 9–15.
8. Gerber, E. M., and Hui, J. Crowdfunding: Motivations and deterrents for participation. *ACM Transactions on Computer-Human Interaction (TOCHI) 20*, 6 (2013), 34.
9. GoFundMe, and project, H. www.gofundme.com/mvc.php?route=category&term=hurricane.
10. Gordon, T. P., Knock, C. L., and Neely, D. G. The role of rating agencies in the market for charitable contributions: An empirical test. *Journal of accounting and public policy 28*, 6 (2009), 469–484.
11. Haas, C. *Incentives and two-sided matching-engineering coordination mechanisms for social clouds*, vol. 12. KIT Scientific Publishing, 2014.
12. Kuppuswamy, V., and Bayus, B. L. Crowdfunding creative ideas: The dynamics of project backers in kickstarter. *UNC Kenan-Flagler Research Paper*, 2013-15 (2015).
13. Lee, Y.-C., Yen, C.-H., and Fu, W.-T. Improving donation distribution for crowdfunding: An agent-based model. In *Social, Cultural, and Behavioral Modeling: 9th International Conference, SBP-BRiMS 2016, Washington, DC, USA, June 28-July 1, 2016, Proceedings 9*, Springer (2016), 3–12.
14. Mollick, E. The dynamics of crowdfunding: An exploratory study. *Journal of business venturing 29*, 1 (2014), 1–16.
15. Parsons, L. M. The impact of financial information and voluntary disclosures on contributions to not-for-profit organizations. *Behavioral research in accounting 19*, 1 (2007), 179–196.
16. Roth, A. E. Deferred acceptance algorithms: History, theory, practice, and open questions. *international Journal of game Theory 36*, 3-4 (2008), 537–569.
17. Salganik, M. J., Dodds, P. S., and Watts, D. J. Experimental study of inequality and unpredictability in an artificial cultural market. *science 311*, 5762 (2006), 854–856.
18. Solomon, J., Ma, W., and Wash, R. Don't wait!: How timing affects coordination of crowdfunding donations. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW)*, ACM (2015), 547–556.
19. Solomon, J., Ma, W., and Wash, R. Highly successful projects inhibit coordination on crowdfunding sites. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM (2016).
20. Tanaka, K. G., and Voida, A. Legitimacy work: Invisible work in philanthropic crowdfunding. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM (2016).
21. USA, G. Giving usa annual report 2015, 2015.
22. Wash, R. The value of completing crowdfunding projects. In *Proceedings of the International Conference on Weblogs and Social Media (ICWSM)*, AAAI (2013).
23. Wash, R., and Solomon, J. Coordinating donors on crowdfunding websites. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing (CSCW)*, ACM (2014), 38–48.

24. Xu, A., Yang, X., Rao, H., Fu, W.-T., Huang, S.-W., and Bailey, B. P. Show me the money!: An analysis of project updates during crowdfunding campaigns. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM (2014), 591–600.

25. Yen, C.-H., Lee, Y.-C., and Fu, W.-T. Improving the efficiency of allocating crowd donations with agent-based simulation model. In *International Conference on Social Computing, Behavioral-Cultural Modeling and Prediction and Behavior Representation in Modeling and Simulation*, Springer (2017), 248–253.