Inferring the Student Social Loafing State in Collaborative Learning with a Hidden Markov Model: A Case on Slack

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ABSTRACT

With the increasingly prevailing usage of Information and Communication technologies (ICT) in collaborative learning, students can cooperate with others online easily, in spite of the restriction of time and location. Social loafing, a common phenomenon in collaborative work, has negative effect on team performance, especially on the individual's knowledge sharing behaviour. In recent years, there are also some researches pointing out that social loafing is a kind of hidden and unobservable behaviour. In this study, we propose a research model based on the stimulus-organism-response (S-O-R) framework and build a hidden Markov model (HMM) to infer the student's unobservable social loafing state. We collect real world behaviour data from an online collaborative course from Nov 11th 2016 to Dec 21th 2016.The dataset includes more than 1200 knowledge sharing records from 150 students on Slack. Our research is expected to contribute in both academic study and managerial implications on how to set up a collaborative team.

Keywords

Social loafing, Centrality, Collaboration work, Knowledge sharing, Hidden Markov models

1. INTRODUCTION

In recent years, students have more access to digital learning tools, including both traditional multi-media classroom and some Information and Communication technologies (ICT). Prior studies have shown that ICT in the classroom can relief students' attention problem [1] and can change the learning way from a teacher focused instructional approach to a student focused collaborative learning model [20]. Collaboration is a critical factor to help knowledge sharing, knowledge development and knowledge implication [3]. There are several specific ICT. And Slack, as a new type of ICT, is a novel communication platform which is originally developed for programmers collaborating remotely on software coding, and is playing an increasingly important role in shaping the way for collaboration and communication [14].

Social loafing is a quite common phenomenon in team collaborative work. In traditional offline team work, loafers take

advantage of the knowledge shared by other team members without sharing their own knowledge with others [3]. Prior research has shown that social loafing has negative impact on knowledge sharing [23]. It has the similar influence in team work supported by ICT [19]. Thus, how to reduce social loafing in team work is important for academics and practitioners [22]. Social loafing is a kind of hidden and unobservable behavior. Inferring social loafing state with observable behavior is also an important issue.

A study group is a social network of students who often collaborate with each other. In particular, researchers have studied the impact of the structural position of members within a network on team performance. Central student will have greater influence on others and take more responsibility [8], which means he/she will share more knowledge in collaboration. With the increasing popularity of ICT practices in collaborative learning groups, there is an increasing interest in understanding how the position in a social network will affect students' knowledge sharing behavior with different social loafing state.

In this paper, we propose a hidden Markov model to infer students' unobservable, evolving social loafing from the observable knowledge sharing records on Slack, which in line with the stimulus-organism-response (S-O-R) framework [9], as used in environmental psychology. Specifically, we examine a student's knowledge sharing behavior in the Slack (R) and perform reverse reasoning to infer the social loafing states (O) with a hidden Markov model, given that we cannot directly observe O but know R and can manage S. Thus, after identifying the students' social loafing state O, the proposed model implements optimal team organization immediately by students' centrality stimuli (S) to influence O to generate positive outcomes R.

2. LITERATURE REVIEW

2.1 Social loafing theory

Social loafing theory (SLT) points out that productivity decreasing in group work is due to the social loafing phenomenon [12]. Social loafing refers that individual will decrease his/her effort in group work compared to individual work [6]. Prior study has found that it is the lack of motivation that social loafing emerges [11]. Liden et al. identified critical factors toward individual's social loafing from two dimensions: group-level factors (i.e., constitution, dispersion and justice) and task characteristics (i.e., task visibility, task complexity) [13].Social loafing can be used to explain productivity losses in work group [15].Several studies in the IS field have also investigated social loafing in the IT-based environment. Piezon found that social loafing is significant in online student groups [18]. Most previous researches studied social loafing with quantitative methods and

regarded social loafing as a static state. In our research, we use observable knowledge sharing records in the Slack to infer the unobservable social loafing states.

2.2 Knowledge Sharing and Social Loafing Behavior

Bukowitz and Williams gave the definition of knowledge sharing that it was an activity through which knowledge, such as skill, information or expertise, could be exchanged among people in communities or organizations [4]. Prior study has confirmed that the use of ICT can support knowledge sharing. Slack is very well suited to help interact with others and share knowledge in collaborative activities. Lin et al. [14] have confirmed that Slack is playing an increasingly significant role in collaborative software coding development, replacing email in some cases and enforcing knowledge sharing between programmers. In the recent years, some researches have focused on the social loafing in knowledge sharing. Lin and Huang confirmed that the negative impact of social loafing was more salient in knowledge contribution group work than in simple group work [15]. Voelpel found that social loafing had negative impact on knowledge sharing in virtual team collaboration [21].

2.3 Students' centralities and Knowledge Sharing

Centrality is an important notion in social network analysis [10], measuring a node's importance in communication or collaboration networks. Centrality indicates the importance of each individual in the social network and the information flow. Previous studies showed that centrality was related to knowledge sharing. Zhi et al found that individual centrality can predict knowledge sharing [24]. Marques et al. showed that central individuals shared knowledge amongst themselves and tended to share more knowledge [16]. And individuals with higher status are also related to more responsibility which means they should do more efforts in the group work, such as sharing more knowledge.

2.4 Proposed Theoretical Framework

Our theoretical framework is based on the extended S-O-R framework in environment psychology, which suggests that an environmental stimulus S influences cognitive internal states O, and further affect response behavior R [17]. In our research setting, students' centrality is the environmental stimulus. Centrality is an individual factor which will influence student's social loafing states, different social loafing states affect knowledge sharing in ICT, such as Slack, differently. Contrasted to normal S-O-R logic, we apply backward reasoning and propose that individual behavior reflects her or his unobserved cognitive internal states [7]. We take a student's R as inputs (knowledge sharing in ICT) to infer unobserved intention O.
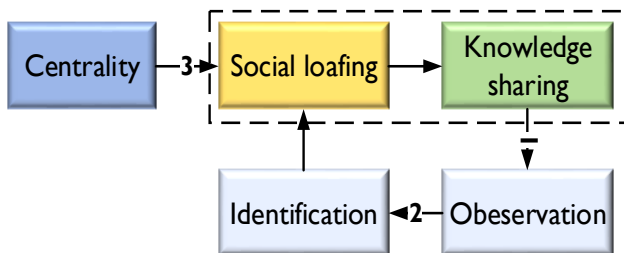

Figure 1. Research framework.

Figure 1 is our framework. We use an observation module to capture the knowledge sharing behavior of each student. A student's social loafing state is unobservable, so the identification module uses the outputs of the observation module to estimate the social loafing state. And we will examine how environmental stimuli, that is centrality, influence students' knowledge sharing behavior with different social loafing states.

3. HMM OF LEARNING STUDENT SOCIAL LOAFING

3.1 Observation Module

The observation module records the talk times for each student per week in the Slack. More specifically, talk times is a count variable, when a student send a message in the Slack during a week, his/her talk times will be added 1. Sending a message or talking to others in the Slack is a kind of knowledge sharing behavior. The outputs of observation module are sequences. $V = \{V_1, V_2, \cdots V_M\}$ is the notation set of observation sequences, $V_i (i = 1, 2, ..., M)$ is the ith notation, O_i is the observed value at time i

3.2 Identification Module

As above mentioned, we intend to infer each student's social loafing state per week from his/her knowledge sharing records per week in the Slack (i.e., infer O from R). Thus, our identification module uses the outputs of the observation module as inputs to analyze the knowledge sharing behavior. With the inference of the student's unobserved state, the module can predict the next possible social loafing state for a student. In this module, we can conclude that the total number of social loafing states is N .S = $\{S_1, S_2, \cdots S_N\}$ is the set of states, S_i (i= 1, 2, ..., N) is a dependable state, q_i is the value at time i. The outputs include a state transition probability matrix A and a confusion matrix B. Where a_{ij} is the state transition probability from S_i to S_j. Where $b_j(k)$ represents the probability that the observation is V_k when the state is S_j.

$$\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix}$$

$$a_{ij} = P(q_{t+1} = S_j \mid q_t = S_i), 1 \le i, j \le N, t = 1,2... \quad (1)$$

$$\sum_{j=1}^{N} a_{ij} = 1, 1 \le i \le j$$

$$\begin{pmatrix} b_1(1) & b_1(2) & ... & b_1(M) \\ b_2(1) & b_2(2) & ... & b_2(M) \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ b_N(1) & b_N(2) & ... & b_N(M) \end{pmatrix}$$

$$b_j(k) = P(V_k \mid S_j), 1 \le j \le N, 1 \le k \le M \quad (2)$$

$$\sum_{k=1}^{M} b_j(k) = 1, 1 \le j \le N$$

3.3 Optimization module

In order to improve the accuracy of each identification, optimization modules are used to optimize the HMM we build above. Figure 2 is the flowchart of this module. Specifically, we use test sequences to update the matrix A, B after each identification.

4. Method

4.1 Data

We collected real world behavior data from an online collaborative course from Nov 11th 2016 to Dec 21th 2016. We downloaded each student's knowledge sharing records in the Slack per week. The data set includes more than 1200 records about 150 students. Knowledge sharing record is a count variable. Figure 3 shows the communication page in the Slack. Ones record in week i will be added 1 if he/she send a message during week i.

4.2 Measuring centrality

We collect the social network data for each group to calculate students' centrality scores. Students rated the frequency (1-6) and depth (1-6) of their interactions with others in their group. Questions are listed in the Table 1. The students pertaining to interactions with others were summed to create a measure of interpersonal tie strength. Eigenvector centrality is a kind of node centrality, if a node is connected to a more well-connected node, its score is higher. A node's eigenvetor centrality is the sum of centralities of other nodes to which they are connected, weighted by the strength of connection [2].

Table 1. Centrality

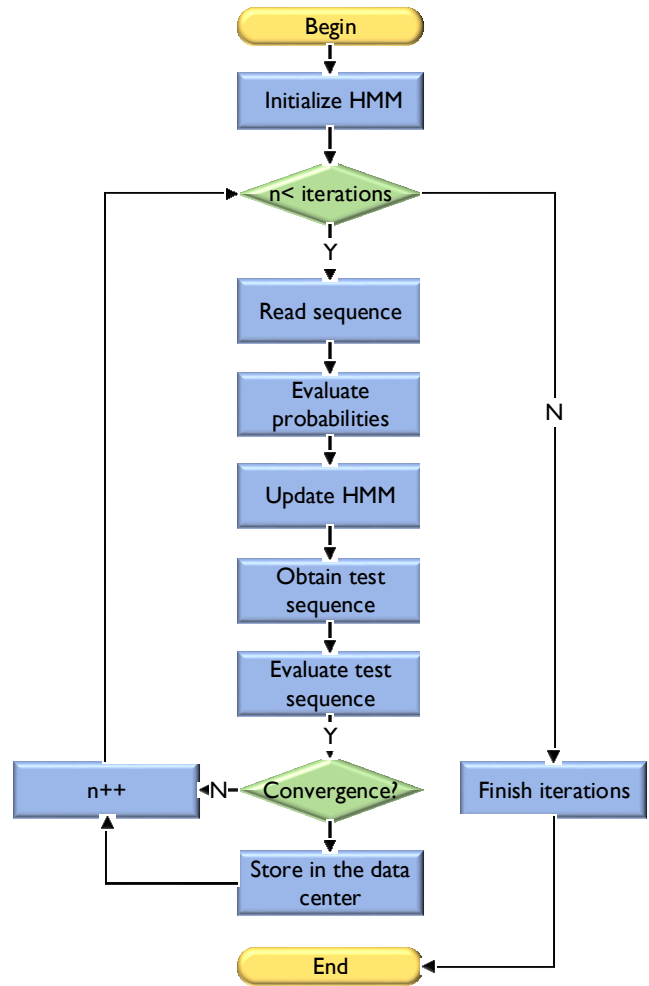| Respondents replied to each question for each person in the group Questions adapted from Burt (1992). |
| --- |
| 1. On average, how often do you interact with this person? (Never, Rarely, Monthly, Weekly, Daily, A few times per day, Hourly or more) |
| 2. How close is your working relationship with this person? (Very Close, Close, Somewhat Close, Somewhat Distant, Distant, Very Distant) |

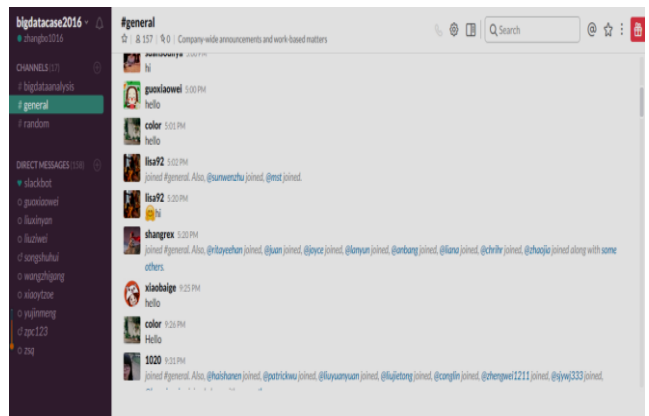**Figure 2. Optimization module flowchart.**

Figure 3. Communication page in the Slack.

5. CONCLUSIONS

This paper outlines a planned study to examine how centralities can influence students' knowledge sharing when they have different social loafing states. The next phase of research will focus on (1) identification performance about learning and identifying the student's unobserved social loafing states while she or he communicates with others through Slack (identification module) and (2) how the centrality as a stimuli influence students'

knowledge sharing behavior with different social loafing states. In details, we will use data mining and machine learning approach to analyze these data and test our model. Finally, these findings will help educators set up an effectively collaborative learning team.

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