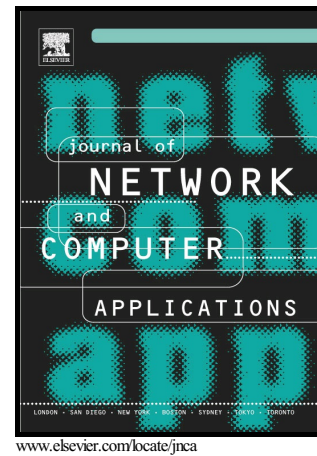


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Yue Zhang, Bin Song, Peng Zhang



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# Social Behavior Study under Pervasive Social Networking Based on Decentralized Deep Reinforcement Learning

Yue Zhang, Bin Song\*, Peng Zhang

*the State Key Laboratory of Integrated Services Networks, Xidian University, 710071, China*

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## Abstract

Pervasive social networking (PSN) provides instant social activities such as communications and gaming, which attracts a growing attention. Under this circumstance, the study and analysis of users' behaviors has a profound meaning, which may be extended to other relevant fields. In this article, we define and quantify users' patterns to study social behaviors, after discussing and reconsidering social characteristics in PSN. Meanwhile, we treat PSN as a market, based on the standpoint that data can be priced and tradable. After analyzing its market structure, we describe PSN as a monopolistically competitive market, which contains multiple providers selling specialized goods. Afterwards, we study the social behaviors in this market from an economic perspective, namely applying market models. Finally, decentralized deep reinforcement learning is proposed to estimate users' patterns and to solve market models, the prisoner's dilemma and the Cournot model to be specific. Simulation results demonstrate the flexibility and efficiency of our algorithms.

*Keywords:* decentralized deep reinforcement learning, market models, monopolistically competitive market, pervasive social networking, social behavior, users' patterns

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## 1. Introduction

The term social networking is initially applied to describe the relationship among humans. Afterwards, the emergence of online social networking (OSN), such as Facebook, allows people construct and maintain social relationship through the Internet. Even though it gathers humans closely, several drawbacks still exist, one of which is the considerable gap between cyber and physical worlds. For instance, friends online may be totally strangers offline, and familiar colleges may share little information via the Internet. Furthermore, online national events, such as election, are injustice and unreliable because they only cover a particular group of people. Therefore, the traditional OSN is more similar to an entertainment rather than a practical tool for social behaviors study and other realistic applications.

With the growing popularity of mobile devices and wireless networks, the spatial and temporal restricts of traditional OSN are becoming negligible, encouraging more people join in OSN, creating pervasive social networking (PSN) (Endler et al., 2011). The emergence

of PSN weakens the boundary between physical and virtual worlds, covering a growing number of users or agents and increasing the possibility of communications among each individual. It may even claim that PSN equips our world with the Internet, making it an inseparable component for our daily life, since its applications cover a variety of daily areas such as communications (Yan et al., 2013), education (Sanna, 2015) or games (Kasapakis and Gavalas, 2015).

Our concern is to study and analyze the social behaviors in PSN so that certain patterns or phenomena could be responded. For instance, we may predict the popularity of a novel product, based on whether this product targets the majority of customers. Meanwhile, for each agent in PSN, the key desire is to find the most appropriate information, which is difficult due to the fuzzy and divergent concept of *appropriation*. Under the environment of PSN, each user could be a potential data provider, where the complicated task is to locate the most suitable candidates.

For that purpose, we analyze social characteristics in PSN, which is slightly different from that of conventional social networking. Those in PSN should be associated with categories of information, due to the multi-

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\*Corresponding author.

*Email address:* bsong@mail.xidian.edu.cn (Bin Song)

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