Engineering Socially Intelligent Personal Agents via Norms
(Doctoral Consortium)

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ABSTRACT

This thesis develops Arnor, an agent-oriented software engineering (AOSE) method to engineer social intelligence in personal agents. Arnor goes beyond traditional AOSE methods to engineer personal agents by systematically capturing interactions that influence social experience. We empirically evaluate Arnor via a developer study, and a set of simulation experiments. We find that (1) Arnor supports developers in engineering personal agents, and (2) personal agents engineered using Arnor provide a greater social experience than agents engineered using a traditional AOSE method.

1. INTRODUCTION

Human interactions in society are not merely driven by personal needs and expectations. Others around us and their expectations play a prominent role on the way we act and interact. A personal agent acts and interacts on behalf of its human user. In this research, I address the research question of how can we engineer social intelligence in personal agents to deliver a pleasant social experience.

A *socially intelligent personal agent* (SIPA) adheres to *social expectations* of multiple *stakeholders*—both *primary* and *secondary*, adapts according to the social context, acts on behalf of its human user, and provides a pleasing social experience to all its stakeholders.

EXAMPLE 1. *Consider a ringer manager as a SIPA. The ringer manager installed on Alice's phone decides appropriate ringer modes (loud, silent, or vibrate) for incoming calls. Alice, the phone owner is the primary stakeholder of the SIPA. Bob, Alice's friend who calls Alice often, and Charlie and Dave, Alice's coworkers, who are in her vicinity, are some of the secondary stakeholders. Further, the ringer manager's capabilities influencing its social experience include (1) allowing Alice to be tele-reachable, (2) notifying the caller if Alice is not reachable, (3) enabling Alice to work uninterrupted, and (4) not annoying Alice's neighbors.*

Suppose that Bob calls Alice when she is in an important meeting with Charlie and Dave. As a friend, Alice is *committed* (a social norm) to answering Bob's phone calls. Another *commitment* is to keep one's phone silent during

important meetings. Alice's SIPA, understanding the norms and knowing that Bob's calls to Alice are generally casual, puts Alice's phone on silent for Bob's call and notifies Bob that Alice is in a meeting; later when Alice's meeting ends, Alice's SIPA reminds her to call Bob.

Should Alice's phone rings loudly during the meeting, privacy implications may follow [5, 8]. A loud ring *intrudes* upon Alice's and other meeting attendees' privacy in that call violates the meeting attendees' reasonable expectation to be left alone. Further, it is likely that meeting attendees frown at Alice (*disapprobation*). If Alice answers the call, those overhearing Alice and Bob's conversation can gain knowledge about her and her interlocutor (*information leak*). If Bob's call were urgent, Bob's SIPA could communicate the urgency to Alice's SIPA, and Alice's SIPA could deliver a different social experience, e.g., set phone on vibrate to notify Alice of urgency and yet not annoy other meeting attendees. Should Alice's phone stays silent for Bob's urgent call, it may affect their relationships.

In the examples above, ringer manager SIPA makes nontrivial decisions influencing social experience of its stakeholders. Existing AOSE methods [4, 10, 6] are good starting point to engineer personal agents, however these methods do not guide developers with systematic steps to represent and reason about such scenarios, and thus fall short in supporting agents that adapt to evolving social contexts at runtime.

Social norms inform SIPAs about a set of reasonable actions in a social context [9]. Norm compliance in a social context is either achieved by (1) conveyance of norms, where SIPAs are made aware of norms by direct communication, or (2) via (positive and negative) sanctions, where SIPAs learn norms in the form of which actions are appropriate in a context [2].

The contribution of this research is Arnor [1], a systematic method to engineer SIPAs. Arnor facilitates developers to model stakeholders' actions and expectations, and how these influence each other. Arnor employs Singh's [7] model of (social) norms to capture social requirements, and incorporates argumentation constructs [3] for sharing decision rationale. Since, testing a SIPA's adaptability in all possible social contexts is logistically challenging and time consuming, Arnor also incorporates a SIPA simulation testbed. We rigorously evaluate Arnor via a developer study and a set of simulation experiments on the simulation testbed. The novelty of the research is that in spirit, Arnor is a hybrid method that addresses the problem of engineering SIPA's by combining both top-down (by modeling) and bottom-up (via experience or social learning) styles.

2. ARNOR

Arnor is a four-step method that guides developers to systematically engineer SIPA's social experience. Arnor's steps include modeling: (1) goals, (2) social contexts, (3) social expectations, and (4) social experience.

Goal modeling enables a SIPA to be aware of its stakeholders, their goals, and relevant plans. Arnor uses Xipho [6] constructs for goal modeling.

Context modeling includes identifying social contexts in which stakeholders of a SIPA interact. The context plays a decisive role in which goals to bring about or which plans to execute during inconsistencies.

Social expectation modeling includes identifying norms and sanctions that govern stakeholders' goals and plans.

Social experience modeling includes identifying SIPA's actions that promote greater social experience, i.e, choosing which plans to execute, which goal states to accomplish, and which norms to satisfy.

2.1 Evaluation

We evaluate Arnor (A) against Xipho (X), an existing AOSE method, via a developer study in which 30 developers engineer ringer manager SIPAs, and simulation experiments under various adaptation environments on the SIPAs engineered during the developer study. We use Xipho as our baseline method because it is best suited among the existing AOSE methods to engineer personal agents. Refer our AAMAS'17 paper [1] for details.

Developer Study. We hypothesize that the developers who follow Arnor (1) produce better models, (2) expend less time, (3) feel it is easier to develop a SIPA, and (4) expend less effort, than those who follow Xipho. We find that developers using Arnor spend less time and effort, and overall feel it is easier to engineer a SIPA using Arnor. No significant difference is found in the model quality. Figure 1 summarizes the time and effort results.
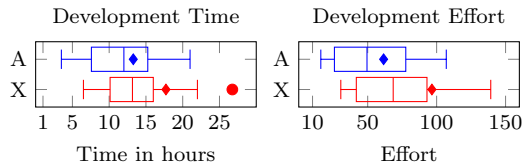

Figure 1: Development time and effort.

Simulation Experiments. We hypothesize that SIPAs developed using Arnor (1) have better adaptability features, and (2) provide richer social experience, than SIPAs developed using Xipho. We measure social experience via norm compliance and sanction proportion measures. We find that SIPAs engineered using Arnor have greater adaptability correctness, similar norm compliance, and are prone to lesser sanctions. Figure 2 summarizes the simulation results for sanction proportion in various adaptation environments.

3. ONGOING AND FUTURE DIRECTIONS

One, when norms conflict, SIPAs must execute actions that promote richer social experience. How can we develop computational support over Arnor to recommend actions?
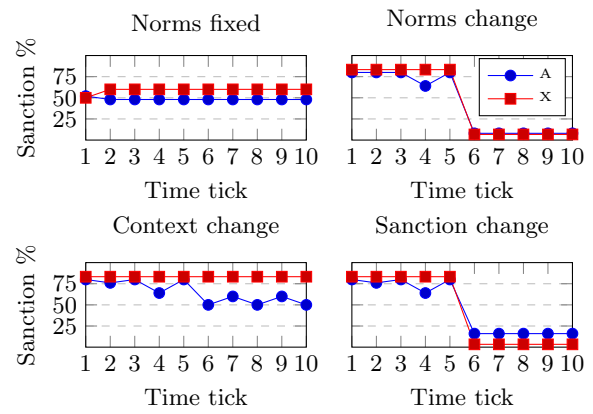

Figure 2: Arnor versus Xipho's sanction proportion.

Two, when SIPAs satisfy or violate norms, they might share certain contextual information related to satisfaction or violation. Social experience largely depends on how SIPAs' stakeholders perceive shared information. How and what contextual information should a SIPA disclose?

Three, an understanding of emotions and affect could assist SIPAs in learning contextually relevant norms. How can we incorporate an affective and emotional basis of social norms in SIPAs?

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