Artifact-Mediated Society and Social Intelligence Design

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Abstract Human society is increasingly dependent on artifacts. The progress of artificial intelligence accelerates this tendency. In spite of strong concern about heavy dependence on artifacts, it appears an inevitable consequence of the knowledge society. In this chapter, I am seeking a better way of living with advanced artifacts to realize an artifact-mediated society where people are supported by human-centered socially-adequate artifacts. The proposed framework consists of surrogates that work on behalf of the user and mediators that moderate or negotiate interactions among surrogates. I survey recent work in social intelligence design, and discuss technological challenges and opportunities in this direction.

1. Introduction

Human society has been dependent on artifacts since the early days of history. Conventional characterization of artifacts is to view them as tools for extending humans or resources that support us as well as artifacts.

Before the first half of the twentieth century, most artifacts extended the physical dimensions of human activities. For example, horse-drawn carriages, steam locomotives and automobiles remarkably extended our capability of moving and carrying, to name just a few. Conventional lifelines such as gas, water and power supplies, roads or railways serve as resources for enabling the activities of ourselves and artifacts. There are some others, though more limited compared with physical extensions, which extend the intellectual dimensions of human activities, such as telephones and broadcasts. The effect of classic artifacts is relatively limited to the local regions (Figure 1). Individuals are relatively isolated from each other and their human relations do not often go beyond local communities.

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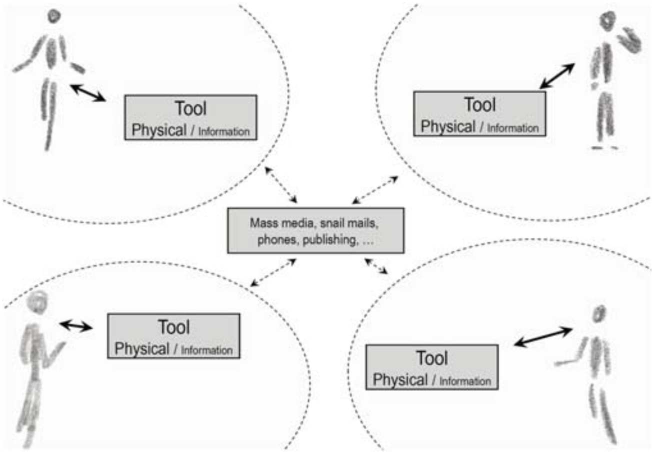


Fig. 1. Classic artifacts.

In the second half of the twentieth century, the invention of computers and the Internet significantly increased the complexity of artifacts. First, it brought about automation everywhere. Modern aircraft are mostly controlled and monitored with computers. ICT (Information and Communication Technologies) enabled intimate integration of mechanism, control and environment. In the case of automobiles, for example, information and communication technologies not only help drivers drive an automobile safely and comfortably, but also make use of geographic positioning and information systems to refer to rich information sources concerning the driving route, parking lots, nearby restaurants or traffic conditions. Moreover, it allows the transportation authority to intelligently control traffic signals to reduce traffic jams, or place an electronic toll collection system to automatically collect a toll charge. Industrial robots are introduced to pursue long and complex assembling tasks very rapidly in factories. Second, computers and the Internet significantly extended the way we think and communicate with each other. They provide facilities for searching as well as information. They not only allow people to talk with each other, but also help people know, meet, collaborate, help and understand each other. As a result, people come to place more value on togetherness and connectedness in life, resulting in the advent of global network communities, such as the Unix, Amazon.com, or Wikipedia communities (Figure 2).

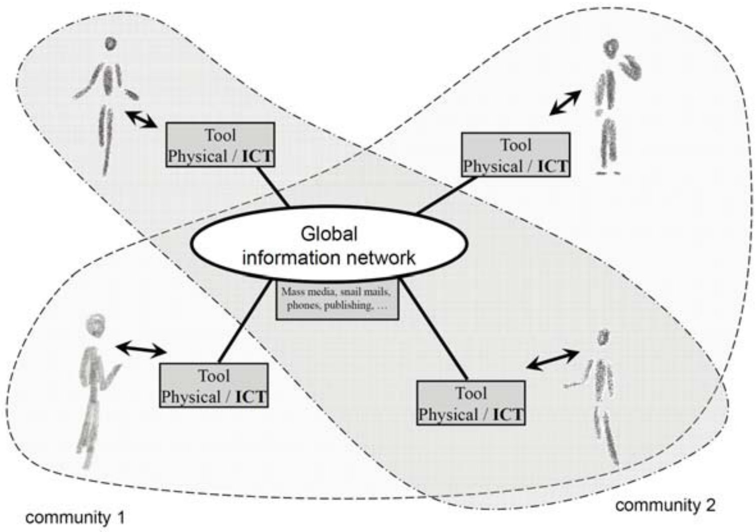


Fig. 2. Artifacts in the information age

2. Contribution of Artificial Intelligence

Artificial intelligence (AI) technologies accelerate the sophistication of artifacts. In its history over fifty years, AI has achieved numerous significant contributions to computer science, including heuristic search, knowledge-based systems, natural language processing and pattern processing, planning, machine learning and data mining. Heuristic search has allowed us to efficiently use partial knowledge to solve heuristically large-scale ill-formed problems, such as Chess, for which the action sequence to the solution cannot be uniquely determined in the course of problem solving due to the incompleteness of knowledge. Knowledge-based systems have enabled us to solve problems by explicitly coding experts' practice. Natural language processing and pattern processing have made computers understand what we speak, see and perceive in general. Planning enables us to implement autonomous artifacts that pursue their mission based on a set of given strategies and tactics. Machine learning permits computers to improve their behaviour based on experience. Data mining enables computers to discover patterns from a large collection of data (Figure 3).

Besides progress in the core technologies, we are witnessing increasingly more practical AI applications in numerous domains. Some remarkable applications, among others, include:

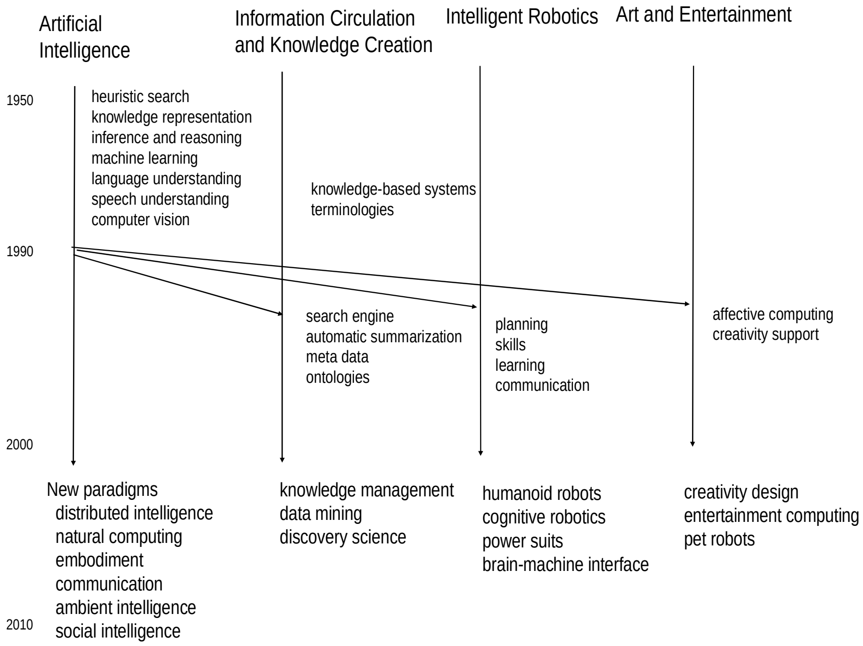


Fig. 3. Artificial Intelligence and adjacent areas

- Web intelligence by connecting a huge amount of knowledge and information made available on the net to solve challenging problems. It ranges from scientific computing to security informatics.
- Autonomous intelligent artifacts such as Mars Exploration Rovers that can explore the unknown environment of the red planet in pursuit of data collection and scientific discovery.[2]
- Intelligent prostheses for supplementing or enhancing human capability in physical, cognitive or social dimensions. This category includes technologies such as advanced safety vehicles that can locate a pedestrian in the dark or brain-machine interfaces that can change thought into physical actions.
- Artist computers that can draw, paint or play music by themselves, by simulating the artistic process. Interactive synthetic characters or artificial pets with emotion / personality models fall in this category.

As a result, AI makes it possible to build artifacts with human-like perceptions that can execute complex social functions (Figure 4). In addition, programming methodology has significantly changed. It is becoming popular for researchers and developers quantitatively to measure phenomena, and have artifacts statistically

[2] http://marsrovers.jpl.nasa.gov/overview/

learn from the training data to cope robustly with complex phenomena. AI will contribute to “dismantling discontinuities in historical ego smashing events”, “the fourth discontinuity - the one between humans and their machine” [Cooley 2007], in particular. Although it is good news in the sense that we can implement artifacts that can work in more complex environments than before, it brings about opaque artifacts beyond our understanding.

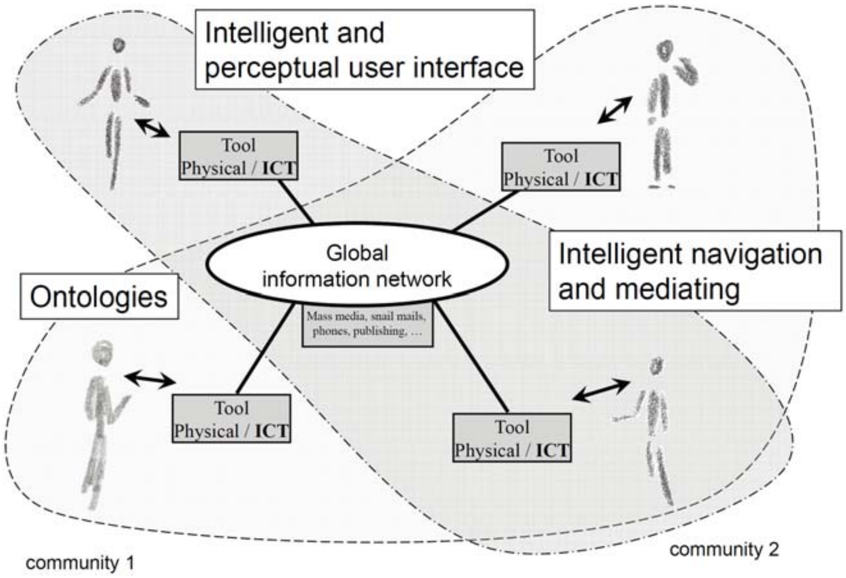


Fig. 4. Artifacts empowered by Artificial Intelligence

3. Difficulties with Complex Artifacts

As artifacts become more intelligent, it becomes harder both for the product producers and consumers to take responsibilities for the artifacts they produce or use. On the one hand, the user cannot completely understand the artifacts so that they may not hurt or annoy other people. Indeed, the complexity of artifacts might significantly hinder their proper use. On the other hand, it is almost impossible for a producer to predict all possible uses of the product and prevent misuse from happening, even though it might be possible to manufacture error-free artifacts. The problem may become more serious with intelligent artifacts such as autonomous intelligent robots. Even though many people might believe the validity of Asimov's three laws of robotics, their complete implementation appears to be impossible, for the robot designers cannot think about all situations her/his robot would be faced with. As a result, nobody might be able to take responsibility for artifacts (the responsibility flaw problem) [Nishida 2007a].

Artifacts might bring about disastrous outcomes if they are applied to illegal or malicious purposes, or even used by a user in panic or caught by a strong antagonistic emotion. The worst example is robot soldiers.

Ethical problems might become evident, for AI technology might extend tacit human thoughts that have not caused serious problems with conventional technologies, for people may not be good at thinking tacit dimensions or society is not entirely familiar with novel problems.

Another problem is that it will cause heavy dependence on artifacts. Individuals might use artifacts without judgment. Society might assume the infallibility of artifacts without rationale. There are strong concerns about heavy dependence on artifacts. Among others, Cooley exhibited a similar concern using “from judgment to calculation” [Cooley 2007], and gave a caveat of being overly dependent on calculation rather than judgment. He warns that the lack of judgment might result in severe failures, such as a fatal dose of morphine more than 100 times the correct amount, which could have been prevented if one were trying to capture the situation with enough sensibility and deliberation. In the meanwhile, the heavy dependence will entirely remove motivations of thinking and imagination at the individual level, and might bring about “empty brains” [Maurer 2007]. Perrow points out the difficulty of sustaining sensibility against accidents as an organization, and accidents might happen normally [Perrow 1984].

Maurer warns that a serious breakdown of the computerized social infrastructure might cause a catastrophic disaster and bring human society back to the Stone Age.

Unfortunately, the heavy dependence on artifacts appears to be an inevitable destiny of mankind. The more artifacts bring about new services, the more human society may depend on artifacts, in order to overcome the complexity. We often use social heuristics to ask friends or colleagues to solve problems rather than try to solve them by ourselves. Such an attitude is often effective, for the modern world is so complex that we know explicitly or implicitly that our knowledge and information is very limited. On the other hand, the more the human society depends on artifacts, the more services may result due to the recognition of novel problems and opportunities (Figure 5).

We have already come too far deeply into “Lushai Hilles” [Cooley 2007]. Although we can see the way we passed, we cannot see what is coming up in the journey. It seems almost impossible to live without being assisted by artifacts in a modern jungle. As the above argument suggests that the difficulties come from human society rather than nature, in the rest of the chapter I will focus on issues related to assisting human society with artifacts.

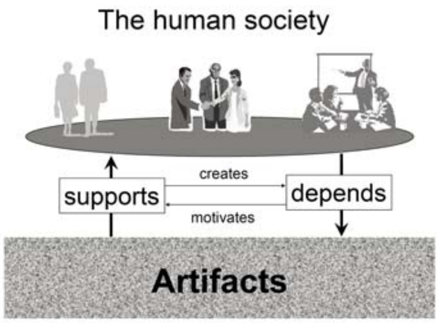


Fig. 5. Heavy dependence on artifacts

4. Towards Artifact-Mediated Society

How can we maximally draw on the power of artifacts without suffering from real and potential dangers? An intuitive answer is to design human-centered socially-adequate artifacts, or *social artifacts*, to realize an *artifact-mediated society*, in which a fully automated mechanism moderates artifacts so that all interactions among artifacts are completely moderated and malicious and inappropriate use can be suppressed or at least recorded for later assessment, even though it is not possible to completely prohibit them. I present the framework and discuss feasibility and challenges for achieving it.

4.1 The Framework

This framework assumes that artifacts mediate social functions. Whenever a person would like to play a social function, s/he is expected to delegate the social function to an artifact called a surrogate that may act on behalf of her/him. Mediators moderate or negotiate interactions among surrogates (Figure 6).

It is very much like people negotiating with each other through their artificial attorneys, who not only try to maximally satisfy the user's intention but also comply with legal and ethical rules shared in society. We called this approach the artifact-as-a-half-mirror approach, for a half mirror is a quasi-opaque object that can both pass light from the back and reflect the real world image. The artifacts in this paradigm may not be completely autonomous or may not be entirely amenable to the owner's intention.

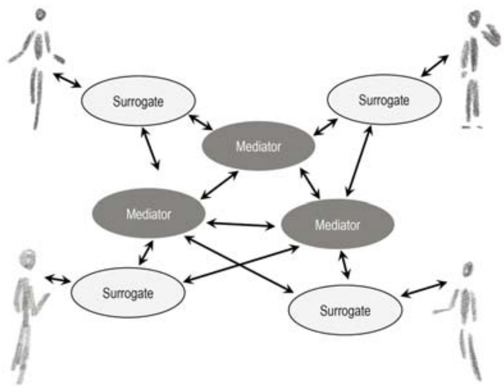


Fig. 6. Information explosion causes more dependence on artifacts

Figure 7 illustrates how the framework is applied to intelligent vehicles. The entire environment is moderated by an intelligent traffic controlling system consisting of mediators. Individual vehicles can be seen as one's surrogate. Unlike conventional automobiles, these intelligent vehicles will attempt to maximize the client's request, such as arriving at a specified destination in a minimal time, only if it is consistent with the public traffic rules and manners. The traffic rules may be designed to be sociable in the sense that intelligent automobiles may yield to pedestrians so long as the client is in a normal condition.

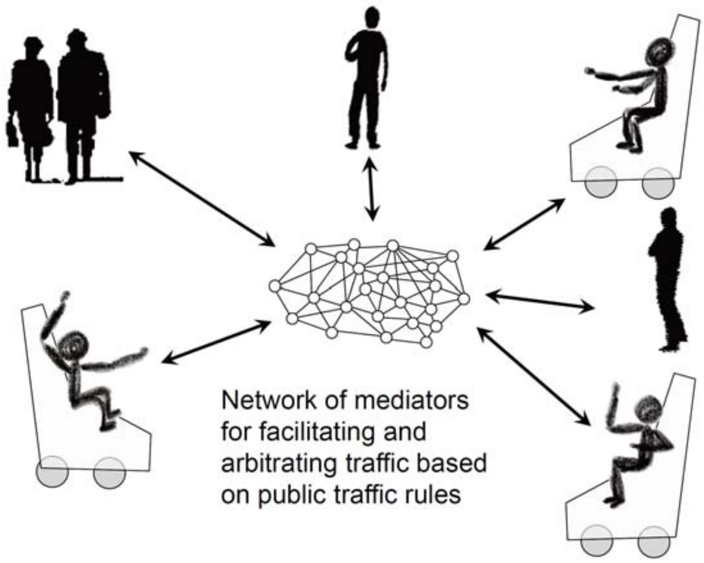
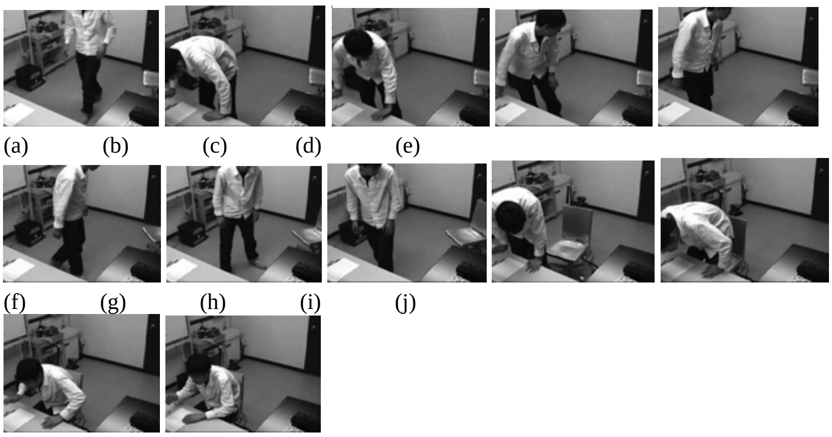


Fig. 7. Moderating intentions to move with autonomous vehicles.

The passengers' intention such as route selection or time constraint may be passed to the socialized automobile and will be reflected in its behaviour so long as it is consistent with traffic rules.

In the autonomous mobile chair project [Terada 2002], the preliminary prototype of an autonomous mobile chair as a surrogate was implemented and tested, while no mediators were used. The autonomous chair was designed to provide a person with a place to sit down. In order to achieve its goal, the autonomous mobile chair was designed to perceive and decrease the geometric distance between its seat back and the surface of the user's body (the back). The optimal action for achieving this depends on multiple factors, such as the shape or locomotive ability of the autonomous mobile chair, or the relative angle of the two surfaces. Reinforcement learning was used to have the autonomous mobile chair learn to move to the goal position in a given situation. Although the mechanism was very simple, the automatic mobile chair worked as if it was intelligently trying to serve the user and the user's reaction toward it appeared relatively natural, as shown in Figure 8.



(a) (b) (c) (d) (e)

(f) (g) (h) (i) (j)

(k) (l)

Fig. 8. Autonomous mobile chair as a surrogate interacting with people [Terada 2002]

Although all the users hired for a small experiment were all able to sit down on the chair as a result of coordinating behaviours, some users pointed out that the autonomous mobile chair should have communicated its intentions more explicitly.

Nishida et al implemented a pair of communication robots (Figure 9) called the listener and presenter robots to elaborate the notion of robot as an embodied knowledge medium for mediating embodied knowledge among people [Nishida 2006]. The listener robot interacts with an instructor to acquire knowledge by videotaping important scenes of her/his activities. The presenter robot, equipped with a small display, will interact with a novice to show the appropriate video clip in appropriate situations where this knowledge is considered needed during her/his work.

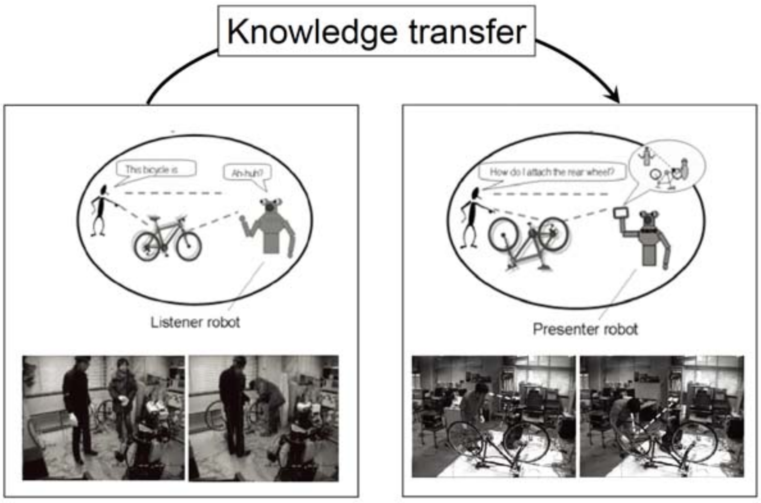


Fig. 9. Listener and presenter robots as embodied knowledge medium [Nishida 2006]

4.2 Challenges

There might be strong objections against using artifacts to mediate human relationships, partly because of the strong influence they might have and partly because of the potential threats of tacit flaws or brittleness to the malicious use or abuse of the machinery. In order for the framework to be feasible and accepted by society, several technical problems need to be solved.

(1) Secure social ground

The first challenge is to establish an artificial social ground for mediators. It should be tightly secured against malicious attacks, such as cyber terrorism.

(2) Secure human-artifact relationship

The human-artifact relationship should be properly established. Some approximation of Asimov's three laws of robotics[3] should be implemented.

(3) Universal usability

The second challenge is to guarantee universal usability so that everybody in society can properly communicate her/his intention to surrogates without much difficulty. To some degree, it is like establishing the trust relationship with a lawyer who is an expert in legal activities. The artifact that possesses sufficient knowledge about the problem should be able to efficiently explain it to the owner in understandable terms. It should decrease existing divides without introducing new divides.

(4) Ethical computing

A theory of justice such as “each person is to have an equal right to the most extensive basic liberty compatible with a similar liberty of others” or “social and economic inequalities are to be arranged so that they are both (a) reasonably expected to be to everybody's advantage, and (b) attached to positions and offices open to all” [Rawls 1999] should be rigorously implemented.

(5) Transparency for social inspection

Public artifacts should be transparent so that society can always inspect them for social adequacy. The rules for programming the public mediation system should be established. The public mediation system should be transparent for inspection.

(6) Cohabitation with legacy system

Progress is always slow. A new innovation should be able to incorporate legacy knowledge accumulated in a conventional knowledge medium.

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[3] (1) A robot may not injure a human being, or, through in-action, allow a human being to come to harm. (2) A robot must obey the orders given it by human beings except where such orders would conflict with the First Law. (3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law [Clarke 1994].

(7) New opportunities and business chance

People are interested in novel things. In order for new artifacts to be accepted in society, it should open up a new frontier in which new discoveries are to be made. It should increase new opportunities for job positions and business. There should be ways for improving and customizing artifacts in many ways, allowing for sophistication.

5. Social Intelligence Design

Issues raised in the previous section may be discussed in the context of Social Intelligence Design whose goal is understanding and augmentation of social intelligence that might be attributed to both an individual and a group. Social Intelligence Design addresses understanding and augmentation of social intelligence resulting from bilateral interaction of intelligence attributed to an individual to coordinate her/his behaviour with others in a society and that attributed to a collection of individuals to achieve goals as a whole and learn from experiences [Nishida 2007b]. Social Intelligence Design can be discussed at the three levels (Figure 10).

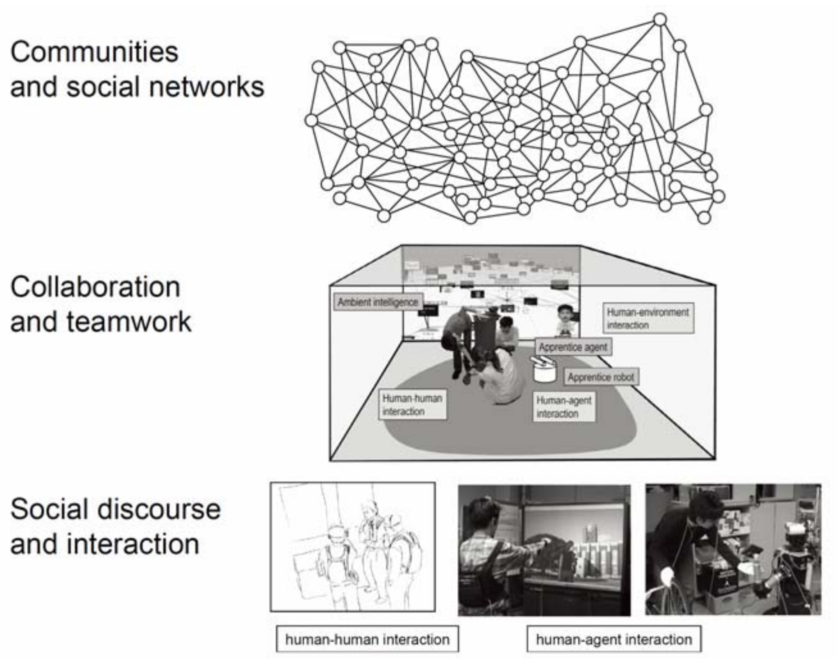

Fig. 10. Framework of Social Intelligence Design

The base level comprises fast interactions at the milliseconds order where social intelligence is used to establish basic communications. The medium level encompasses collaboration in a small group to coordinate joint actions. The top level manifests at the community level to integrate individual intelligences into a collective one. The common methodology is intimate integration of analysis and synthesis based on measurement and quantitative modeling of social interactions, ranging from the small and fast to the large and slow.

5.1 Social Discourse and Interaction

Means of non-verbal communication such as pause, prosody, eye gaze, facial expressions, head movement, hand and body gesture, and so on constitute a basis for social discourse and interaction. Some of these behaviours are intentionally produced by a communication partner for a communicative purpose, while others, such as a subtle correlation of eye gaze and mouth movement, are not. In face to face communication, humans are considered to evaluate each other by sensing such unconscious, uncontrollable non-verbal behaviour.

Kendon and McNeill originated detailed studies on non-verbal communication [Kendon 2004; McNeill 2005]. The discourse and task level information needs to be taken into account to see the role and function of each piece of communication behaviour in the context of the entire discourse or task. Sacks introduced a concept of a turn-taking system in conversation, which suggests rules governing social interactions in conversation [Sacks 1974]. Multi-party face-to-face conversations such as those taking place at poster presentations are interesting as a subject for investigating mutual dependency between the task structure and the non-verbal communication behaviours. In the theory of participation status and framework, Goffman introduced such notions as side participants, bystanders, eavesdroppers in addition to the speaker and the addressee, in order to analyze the behaviour of actors related to a conversation [Goffman 1981].

In order for surrogates to be able to establish and maintain reliable and smooth communication with the owner, principles uncovered by detailed study should be identified and incorporated. Recent progress of measurement technologies using devices such as motion capture or eye tracker has made it possible to capture non-verbal behaviours in real time. It allows for building quantitative and computerized models for building communicative artifacts.

Conversational Informatics is a field of research for studying conversation from wider points of view encompassing conversational artifacts, conversational contents, conversational environment design, and conversation measurement, analysis, and modeling [Nishida 2007c]. A number of attempts have been made to build embodied conversational agents or communicative robots that can interact with people in a natural fashion. Kipp et al propose a data-driven approach to synthesizing natural hand and arm gestures in a continuous flow of movement

[Kipp 2007]. Nakano shows that the grounding behaviours observed in human-human interaction can be effectively used to establish grounding with an embodied conversational agent [Nakano 2007]. Gratch et al reported experimental evidence that even the simple contingent non-verbal behaviours of virtual agents can contribute to establishing rapport with humans [Gratch 2007]. Kopp et al studied a framework for the feedback mechanism from a virtual agent for signaling how internal states of the listener evolve [Kopp 2007a].

Nakano and Nishida analyzed attentional behaviour in human-human interactions, and implemented the findings on embodied conversational agents. Mack can detect the user's attention to a shared referent and use attentional information to judge whether linguistic messages are grounded or not. IPOC can detect the user's attention on the display to estimate the user's interest and engagement in the conversation [Nakano 2007]. Sidner and Lee pointed out that attentional gestures such as following the looking gesture of a human partner, or displaying looking ability such as turning back to look at a human interlocutor after pointing at objects in the room contribute to sustain the sense of engagement in human-robot interaction [Sidner 2007].

André studied how face threats are mitigated by multimodal communicative acts. They conducted a user study, and revealed that gestures are used to strengthen the effect of verbal acts of politeness [Rehm 2007b]. Mohammad and Nishida studied how a social robot can express its internal state and intention to humans in a natural way using non-verbal feedback [Mohammad 2007].

Based on the "computers are social actors" paradigm, Nijholt claims that including the generation of humour and the display of appreciation of humour is useful in human-agent interaction, just as in human-human interaction [Nijholt 2007].

Kopp et al reported that there was experimental evidence for a systematic relationship between visual characteristics of the gesture form and the spatial features of the entities they refer to, though there are quite a number of false negatives. They implemented an integrated, on-the-fly planner that derives coordinated surface forms for natural language and gesture directly from communicative goals [Kopp 2007b].

From the computational point of view, fundamental principles, such as affordance, entrainment, repetition, or mutual adaptation may be needed to implement robust communicative functions. In order to increase the believability and lifelikeness of artifacts, Poel et al studied functions and effects of gaze behaviour and implemented it into a pet robot [Poel 2007]. The design of the resulting gaze behaviour system includes the gaze shifts, vergence, the vestibulo-ocular reflex and smooth pursuit. Rehm et al applied social theories, such as social impact or social influence theory to study how the user can interact with the agents to get in the agents' social network in a 3D meeting place for agents and users [Rehm 2007a].

In order to build a continuously evolving relationship with the user, a robot should be able to put itself in a mutual adaptation process (a similar phenomenon between multiple learning agents being adapting with each other). Xu et al [Xu 2007a; Xu 2007b] described a three stage approach consisting of a human-human WOZ experiment, a human-robot WOZ experiment, and a human-adaptive robot experiment, trying to build a prototype based on the observation of how people adapt with each other and how people improve the protocols for interacting with robots.

5.2 Collaboration in Small Groups

The main task of mediators is to coordinate behaviours of surrogates for collaboration. Computational aspects of collaboration have been widely studied in computer science, in particular, distributed systems and multiagent systems research. Numerous techniques of automatic resource allocation have been developed and deployed for implementing operating systems or controlling network traffic. Numerous intelligent algorithms have been developed in the research on Multi Agent Systems to negotiate agents possibly with conflicting goals, such as distributed search, problem solving and planning, distributed rational decision making including dynamic resource allocation or coalition formation, multi agent learning [Weiss 1999], and so forth.

Social communications at the higher level are for more abstract social interactions including information sharing, collaboration, negotiation, contract making, coalition, arbitration, and so on. Accordingly, the detailed study of human behaviour is vital to study high-level social interactions and their functions.

Awareness is considered to be a key for collaboration based on the viewpoint of helping people collaborate with each other by providing a context for activities. Other benefits of awareness include sharing knowledge, experiences, and feeling of connectedness. In the meanwhile, providing awareness may introduce additional costs in privacy or obligations. Markopoulos discusses the methodologies of evaluation, based on experiences with the evaluation of awareness systems [Markopoulos 2007].

Attempts have been made to observe how information media are used to help collaborative work in global teamwork or video conferences [Mark 2001; Fruchter 2001]. In addition to interaction support, information sharing is critical to enable collaboration. Recent studies involve higher order functions such as persuasion, shared understanding, ontologies, conflict negotiation and workspace design. Lievonen and Rosenberg identify space, place and setting as key notions for analyzing the impact of information and communication technologies for the design of the workspace [Rosenberg 2005].

[Stock et al 2007] propose a technology for enforcing collaboration for shifting attitudes of participants in conflict and demonstrate a collaborative tabletop interface aimed specifically for the task.

Merckel and Nishida propose using space as a reference to shared knowledge in a group [Merckel 2007]. They are developing a system called SKM (Situated Knowledge Manager) that can associate conversation quanta on varying places in the environment. An augmented reality system is being developed to retrieve the spatial coordinates in the real world from corresponding two-dimensional image points. Special emphasis is placed on minimizing the overhead for building the spatial model of the environment and operations, for if it involves extra work, it is not sustainable in a practical way.

Okamura et al [Okamura 2007] developed an augmented conversational environment for sharing in-vehicle conversations in a group. Special-purpose sensing techniques were used to capture the conversational situations in a driving simulator. For example, the system can ground the conversation on the events observed through the simulated window of the vehicle, by analyzing pointing gestures of the participants.

5.3 Communities and Social Networks

In order to analyze and design interactions in the large, we need viewpoints concerning human relationships such as communities or social networks [Kim 2000; Wenger 2000]. Recently, the community concept has received much attention in various contexts, such as open source communities related to the development of open source software such as Linux, SQL, or XOOPS, Web 2.0 [O'Reilly 2005], consumer communities such as Amazon.com[4] or MovieLens,[5] social networking services, or community maintained artifacts of lasting value such as Wikipedia[6]. Although some social functions at this level have been addressed, such as auction protocol [Yokoo 2005], they are rather limited. Instead, various kinds of community support systems have been proposed, developed and evaluated, most notably and deployments to support real communities.[7]

AI technologies are more concerned with higher level functions such as community display and analysis, social navigation and search, social matchmaking, event support, dispute resolution, and large scale discussion and decision making, which are being built on top of base functions such as membership management and communication infrastructure.

Community display and analysis helps the user understand her/his own community and find opportunities to contribute, as well as utilize the community asset. A classic example of community display is Referral Web which can display

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[4] http://www.amazon.com/

[5] http://movielens.org/

[6] http://wikipedia.org/

[7] For example, http://www.cii.uiuc.edu/projects

the human network by connecting pieces of human relations such as co-authorship [Kautz 1997].

Social navigation is a technique for making use of various kinds of footprints [Waxelblat 1999] of other members of a community. A classic example is social book marking [Keller 1997]. Collaborative web search is a search technique reflecting community interests and preferences by making use of previous searches of a community member with whom a common interest or preference is shared [Coyle 2007].

Social matchmaking facilitates the formation of human networks by recommending people who are considered to share common interests [Foner 1997]. Cosley proposes a method called intelligent task routing for automatically matching the human and the task in member-maintained communities [Cosley 2007].

Event support is a suite of facilities for supporting community organizers to hold regular events for community members. The ICMAS'96 Mobile Assistant Project is a classic example that encompasses communication service, Action Navigator for providing information about conference site and vicinity, and InfoCommon for managing personalized information [Nishibe 1998]. Larger experiments include JSAI[8] Integrated Support System [Nishimura 2004] and CHIplace [Churchill 2004].

Dispute resolution and security are critical to maintain communities, for disputes and threats may discourage the participation of members. Mehta shows a method for detecting a profile injection attack to a collaborative filtering system [Mehta 2007].

Large scale discussion and decision making help community members exchange opinions and make decisions. Hurwitz discussed items to be considered to implement a large-scale discussion system on the net, based on the development and deployment of The Open Meeting [Hurwitz 1995]. Erickson introduced social translucence and proposed social proxy [Erickson 2007]. He implemented a system called Babble for a large scale discussion.

Sociological aspects such as workplaces or digital divide need to be considered and assessed [Rosenberg 2005; Blake 2004]. Conte and Paolucci study the effect of reputation on social networks [Conte 2007]. Caire studies conviviality as a mechanism for reinforcing social cohesion and as a tool for reducing mis-coordination between people [Caire 2007].

6. Future Perspectives

The survey in the previous section suggests that there is still a long way to go until the agent-mediated society is realized, concerning higher-level social functions in

[8] JSAI stands for Japanese Society for Artificial Intelligence.

particular. Accordingly, it might be reasonable to set as an intermediate goal the framework as shown in Figure 11, where humans make high-level decisions with information support for basic social functions.

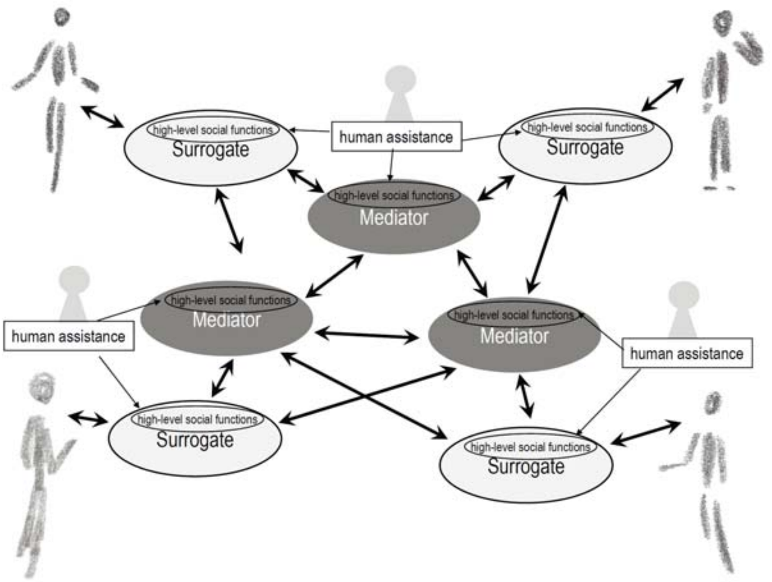

Fig. 11. Intermediate goal for the situation discussed in Section 5.2.

Although the challenges presented in Section 4.2 can be satisfied only partially, we can gradually proceed with high-quality artifacts based on the current technologies. High-level social functions may be gradually replaced by artifacts by analyzing and incorporating the log data obtained from human-human interactions. Small-scaled social experiences will be extremely useful to obtain concrete information about how people behave in the social context, though empirical approaches based on field studies are indispensable to embed the artifacts in society.

7. Conclusion

In this chapter, I have discussed how Artificial Intelligence is a two-edged sword. On the one hand, it allows us to create intelligent artifacts with human-like perception and cognition. On the other hand, it accelerates people's heavy dependence on artifacts. I have discussed how to design human-centered socially-adequate artifacts. I have surveyed work related to social intelligence design and shown a future perspective.

Future work includes elaboration of ideas brought about in this chapter. In particular, drawing a 'roadmap' appears to be most effective, for it requires broad discussions across disciplines from human study and social science to engineering. Development of new technologies by integrating Artificial Intelligence with state-of-the-art measurement and interpretation techniques to bring about new insights based on human and social contexts appears to be a promising next step.

Acknowledgment

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