Social Intelligence Design and Communicative Intelligence for Knowledgeable Community

Toyoaki Nishida
The University of Tokyo, Bunkyo-ku, Tokyo, Japan
nishida@kc.t.u-tokyo.ac.jp

Abstract

In the network age, knowledge evolves at every moment. Community plays a critical role in the sense that it provides people with a competence of dealing with the complex and dynamic nature of the information world. In order for a community to function effectively, an effective circulation of information need to be established. In this talk, I argue for communicative knowledge media that allow for accumulating knowledge in a form usable in conversational context and show how it is applied to community support systems. I show a research agenda towards communicative knowledge media.

1. Introduction

Computer-mediated communication over the ubiquitous network has drastically changed the nature of knowledge. Knowledge evolves at every moment by incorporating new thoughts arising in the history. People or organizations cannot be competent unless they continually evolve their knowledge by incorporating new information.

Community, a collection of people who build and exploit the common context, plays a critical role in the network age in the sense that it provides people with a competence of dealing with the complex and dynamic nature of the information world. A community serves as a ground for creating both tacit and explicit knowledge (Fig. 1). Community of practice, a group of people who share common work practice, develops informal networks of relationships cutting across organizational boundaries in search for better cooperation [1]. Those social networks not only enable the organization to accomplish tasks faster or better but also create novel knowledge.

In order for a community to function effectively, an effective circulation of information need to be established. Unfortunately, there are numerous factors that may hinder information circulation in a community.

Social Intelligence Design is a new research area aimed at designing a new computer-mediated communication systems for supporting community knowledge process and human networks based on in-depth understanding of intelligence as a social phenomenon, which have been called "social intelligence" [2].

Conventionally, social intelligence has been discussed in the context of an individual's ability, e.g., an ability to be able to manage relationship with other

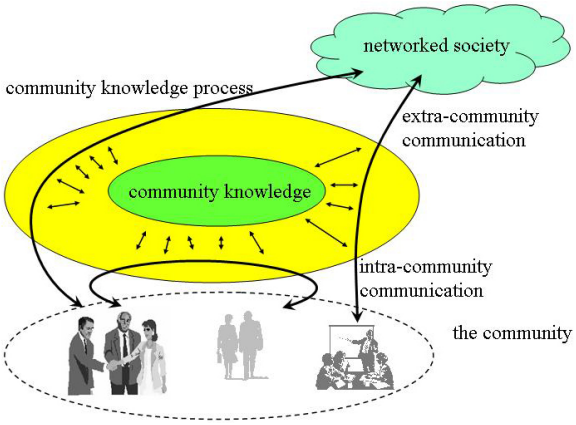

Fig. 1. The role of community in the network society.

agents and act wisely in a situation governed by an implicit or explicit set of shared rules, based on an ability of monitoring and understanding other agents' mental state. It is distinguished from other kinds of intelligence such as problem solving intelligence (ability to solve logically complex problems) or emotional intelligence (ability to monitor one's own and others' emotions and to use the information to guide one's thinking and actions).

Alternatively, social intelligence might be attributed to a collection of agents and defined as an ability to manage complexity and learn from experiences as a function of the design of social structure. This view emphasizes the role of social rules or culture that constrain the way individual agents behave. We might attribute a good social behavior to a good social structure and consider that a good social structure affords the members of the community to learn from each other.

Issues that have been discussed in the context of Social Intelligence Design involve:

- methods of establishing the social context
- embodied conversational agents for social intelligence
- collaboration design
- public discourse
- theoretical aspects of social intelligence design
- evaluations of social intelligence
- applications.

In this paper, I present a suit of communication support tools that facilitate information circulation in a community by providing people with sufficient support of organizing their knowledge in a communicative fashion. Our tools not only provide the user a handy means of producing an engaging presentation but also help the user accumulate materials using *communicative knowledge media* from which a presentation can be readily produced. In addition, our tools integrate personal and community support. Particular emphasis is placed on the use of conversational media as a means for communicating knowledge.

I describe how the above consideration is designed and implemented as a framework of augmenting the knowledge process of communities, featuring embodied conversational agents driven by knowledge cards and the knowledge channel for strategic control of information stream. Then, I briefly overview an ongoing research project aiming at developing intelligent media technology for supporting content production with communicative knowledge media.

2. Communicative Knowledge Media

Communicative knowledge medium provides a means for representing knowledge for use in communication in the personal or community context.

2.1 Components of Communicative Knowledge Media

A communicative knowledge medium comprises knowledge documents, information landscape, and conversations (Fig. 2).

Documents are the most popular means of communicating ideas over the Internet. Multimedia hyper documents provide a powerful means for encoding knowledge. WWW enables us to easily disseminate document world-wide. The story structure, which is a causal understanding of the world is a key to make each document intelligible, as suggested by Schank [3].

Landscapes allow for spatially representing knowledge. A landscape enables the user to visually grasp the global nature of knowledge, explore the information space, and accommodate new information at an appropriate place (Fig. 3).

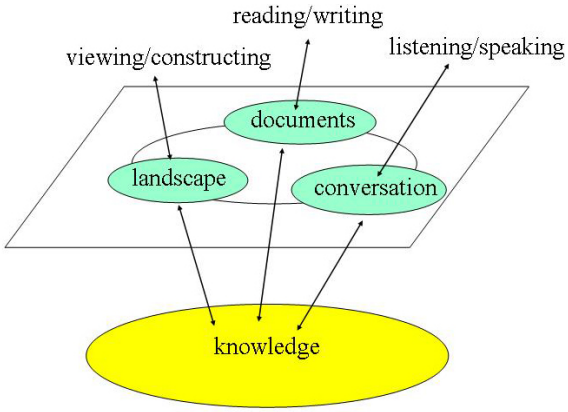

Fig. 2. A framework of communicative knowledge media.

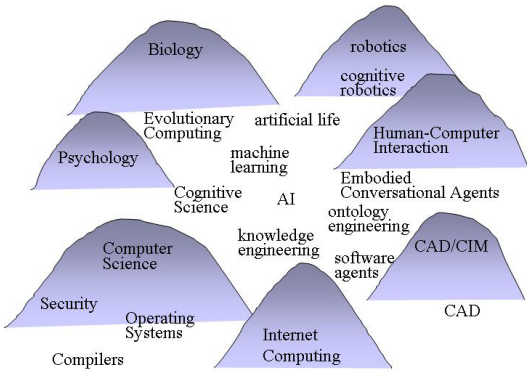

Fig.3. Landscape as a spatial representation of knowledge. This figure illustrates an "AI-centered view" of the research fields. It may look considerably differently when other subjects are chosen as the center.

Conversation enables an effective presentation of knowledge in an interactive fashion. Conversations not only provide the most natural communication means but also facilitate the functions of knowledge creations, as discussed in the next subsection.

2.2 Characteristics of Conversation as a knowledge medium

Among others, conversation brings about heuristic production of stories from different points of view, tacit-explicit knowledge conversion, and entrainment to the subject.

(1) Heuristic production of stories from different points of view

Conversations allow a heuristic composition of stories in a style agreed by a community. In each conversation, attempts are made to structure fragments of knowledge pieces, either tacitly or explicitly possessed by participants into a larger pieces of knowledge in search for possible viewpoints, connections and clusters to encompass the given collection of pieces.

Conversation is an improvisational social process

in which agents from different viewpoints collaborate and negotiate from time to time in search for the social and personal satisfaction. The flow of conversation changes dynamically according to micro-macro interaction of participants' thought.

(2) Tacit-explicit knowledge conversion

Messages communicated with conversations are on the boundary of tacit and explicit knowledge. Conversations give a good opportunity and motivation to externalize tacit knowledge. In discussions, each participant tries to figure out the idea into expressions that have an intended effect, such as propose, counter propose, support, challenge, negate, etc, in the conversational discourse. In debate, participants try to be the most expressive, in search for new points to win the game.

On the other hand, people can make conversation or discussion to examine the given subject from different points of view. Exercises of applying knowledge may allow people to find and socialize how pieces of knowledge are associated with each other and identify a critical cluster of knowledge that is most relevant to the discussion (Fig. 4).

(3) Entrainment to the subject

In order to understand the given subject deeply, one should be involved in the subject and capture the problem as her/his own. Conversations tend to entrain the audience by providing enough sympathy, facilitating to simulate the role of a playing character (Fig. 5).

Conversations will facilitate reality sharing, for they reflect how people articulate the world. Conversations will support social awareness, for they provide a handy means for communicating references to other people and events that the speaker consider worth communicating. It will help context sharing in a community, for conversations often encourage people to explicitly think about the issues in a community that are tacitly shared in the community but not written in anywhere. Even though conversations may not directly address dispute resolution or supporting large scale arguments, they contribute to establishing a firm ground for mutual understanding with a dense collection of daily thoughts.

In the meanwhile, conversations have limitations. Logically precise arguments or visual information are not well communicated by spoken language alone. Furthermore, conversations are volatile. Both the content and the context may be lost quite easily, for it is difficult to reproduce the same mental state as the situation where the conversation was made. Even though conversations are recorded, it is pretty hard to recover the implications of conversations after the conversation session or correcting the transcript is time consuming, tedious task. These weakness should be compensated by advanced information and communication technology if conversation is to be

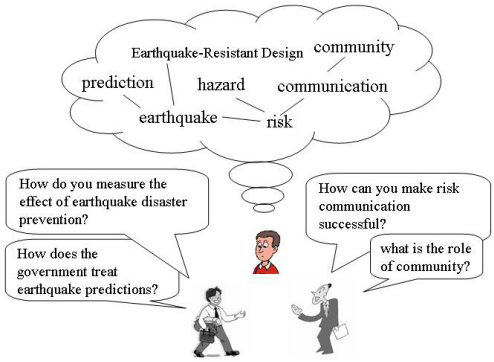

Fig. 4. Conversation as interface between tacit and explicit knowledge.

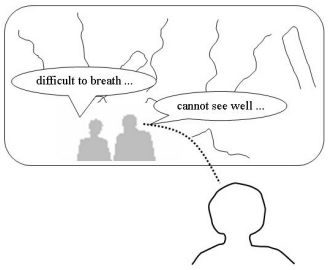

Fig. 5. Conversation brings about sympathetic understanding of the subject.

used as a primary means of communicating knowledge.

Recent advent of intelligent media technology makes it feasible to develop a conversation-centric knowledge medium that takes advantage of conversations while compensate for limitations.

2.3 Conversational Knowledge Process

The conversational knowledge process is a term we coined to refer to a collective activity for knowledge creation, management, and application where conversational communication is used as a primary means of interaction among participating agents. It refers to the collection of community-wide concurrent processes of conversations that contribute to community knowledge creation. The conversational knowledge process serves as a main thrust for accumulation and use of very high density information about a given subject which is invaluable for understanding not only issues related to the subject but also people in the community.

In the conversational knowledge process, co-evolution of conversation, documents, and landscape take place, as shown in Fig. 6.

Conversation making is a process for adapting story pieces into utterances in each scene of a conversation. Various types of transformation are needed to tailor each piece of information so that it can be appropriate in the context.

Story making is a process of composing well-structured stories from a given sequence of

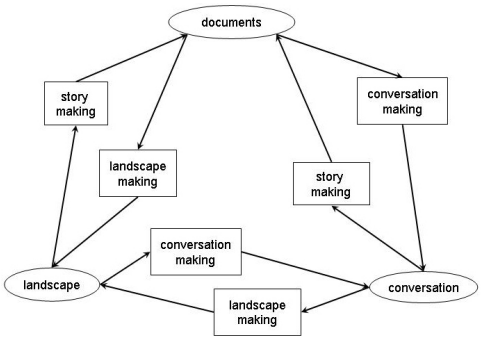

Fig. 6. The essence of conversational knowledge process.

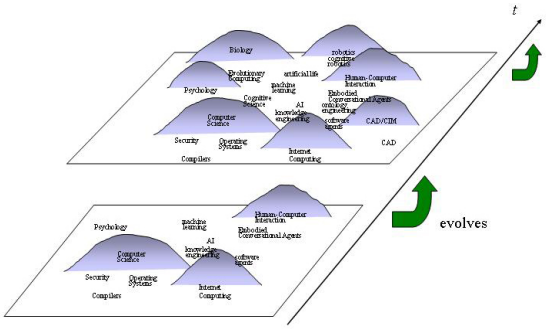

Fig. 7. Evolution of landscape.

utterances. It involves seeking for an optimal story structure that can incorporate conversation fragments, changing the tacit conversational knowledge into explicit representation, transforming components of information representation into those with a uniform grain size, and so on.

Story and conversation making are activities of creating stories or conversational utterances by articulating information resulting from exploring one or more landscape. Landscape making is an activity of producing landscapes from story or conversation archives. Landscapes will evolve as new information is curved into the archive (Fig. 7).

3. Computational Model of Conversational Knowledge Process

I present a computational model of conversational knowledge process using several ideas including quantized conversation, stories, embodied conversational agents, knowledge channel, memory manifold, and knowledge server.

(1) Quantized Conversation
We handle articulated conversation, called quantized conversation and use a knowledge card to represent the content of quantized conversation. Each knowledge card is relatively self-contained package of tacit and explicit knowledge, enabling one to implement a rather robust conversational system without introducing a complex discourse generation algorithm.

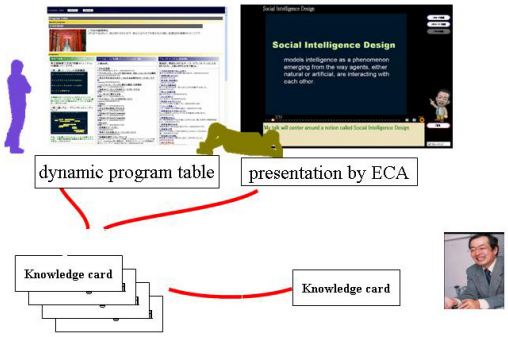

Fig. 8. A general framework of the knowledge channel approach.

(2) Stories
Story is a sequence of knowledge cards, representing a complete story with a plot. In a story, preceding and succeeding knowledge cards give a discourse to each knowledge card.

(3) Embodied Conversational Agents
Embodied conversational agent (ECA) is a device for playing stories consisting of knowledge cards. An ECA employs paralinguistic and nonlinguistic conversational means to control information flow in a conversation. In normal settings, each ECA stands for an existing real person. Accordingly, the conversation partners can recognize whom the ECA talking in front of them stands for. This provides proper background information for interpreting messages from the ECA. Meanwhile, we might well employ anonymous ECAs in certain situations where we want to facilitate communication.

(4) Knowledge channel
Knowledge channel is a mechanism for strategically controlling the flow of knowledge cards. This will contribute to designing long-term interaction by controlling the flow of knowledge cards. Knowledge channel is a conduit connecting a server and a client where knowledge card flow is controlled strategically. Both the knowledge card server and the knowledge card client can control the knowledge card flow using the knowledge channel control policy.

(5) Memory Manifold
Memory manifold serves as a container that allows for spatially accumulating memory items for producing landscapes.

(6) Knowledge Server.
A knowledge card server stores knowledge cards and provides them for knowledge card clients.

This approach approximates the conversational knowledge process with existing technologies, and it can be extended by advanced technologies such a dialogue engine [4]. Tacit knowledge can be embedded into each knowledge card such as visual images or sound, even though it cannot be encoded into knowledge representation. The current natural

Fig. 9. EgoChat: normal presentation mode by a single agent (left), Question mode where the user's question is read by an avatar (right).

language processing techniques such as document classification or summarization may be applied to turn the collection of knowledge cards into a structured knowledge.

4. EgoChat as a Conversational Knowledge Process Facilitator

EgoChat is a system for enabling an elaborate asynchronous communication among community members [5]. It is based on the talking-virtualized-egos metaphor. A virtualized ego is a conversational agent that talks on behalf of the user. Each virtualized ego stores and maintains the user's personal memory as a collection of knowledge cards and presents them on behalf of the user at appropriate situations. It helps the user not only develop her/his personal memory but also better understand other members' interest, belief, opinion, knowledge, and way of thinking, which is valuable for building mutual understanding. We use a powerful dialogue engine that permits a virtualized ego to answer questions by searching for the best match from a potentially large list of question-answering pairs prepared in advance (Fig. 9).

EgoChat provides a couple of unique features. First, it integrates personal and interpersonal knowledge life cycles. At earlier stages of the lifecycle when knowledge is not well captured, the user might want to describe her/his idea as one or more knowledge card and have the virtualized ego present them for personal review. After a while when the knowledge becomes clear and evident to the user, s/he might want to delegate her/his virtualized ego to her/his colleagues to present the idea and ask for critiques. The automatic question answering facility of EgoChat will encourage the audience to ask questions or give comments. The virtualized ego can reproduce the question-answering session with the audience so the owner can review the interactions. It will highly motivate the owner to supply more knowledge or improve existing knowledge for better competence.

Table 1. Four strategies for the knowledge channel policy

	Static scheduling	Dynamic scheduling
Intra-channel arranging	**Order strategy** Giving the outline of the content (messages and channels) in a channel ・course <[*message* | *channel* | (*a set of content*, sorting [*by title* | *category* | *length* | *rating* | *activity* | *author* | *date* | *keyword* | ...], order [*ascendant* | *descendant*]) | ... >	**Access strategy** Changing the stream of the content depending on the interaction and the situation ・browsing [{(behavior [*play* | *skip* | ...], condition [*always* | *in events* | ...], permission [*all* | *members* | *owner* | ...]), ...} | *null*] ・contribution [{(action [*post* | *query* | *rate* | *create* | ...], condition [*always* | *in events* | ...], response [*agent replies* | *content changes* | *never* | ...], modification [*add the message* | *change the rating* | *never* | ...], permission [*all* | *members* | *owner* | ...]), ...} | *null*]
Inter-channel arranging	**Link strategy** Giving a connection with other channels ・loopback [*loopback* | *null*] ・channels [{(*channel*, elements {*channel name*, ...}), ...} | *null*]	**Interchange strategy** Navigating channels ・navigation [{(*target channel*, behavior [*branch* | *merge* | *parallel* | ...], condition [*always* | *in events* | ...], permission [*all* | *members* | *owner* | ...]), ...} | *null*]

<x1, x2, ... > represents ordered elements, {x, y, ...} represents unordered elements, [x | y | ...] represents x, y or other elements and (x, y , ...) represents a set of elements, where elements x and y are defined contextually.

Fig. 10. Example of dynamic program table.

Second, EgoChat allows for describing a channel policy that is used to define the control strategies of the sender and the receiver. Four types of strategies are identified depending on whether the strategy is about the order of programs in a single program stream or about the way multiple program streams are mixed, and whether the program scheduling is static or dynamic, as shown in Table 1. The skeleton of the actual flow structure of knowledge cards for a given pair of the sender and receiver is determined by resolving constraints of their channel policies. It can be visually presented to the user by the dynamic program table, as shown in Fig. 10.

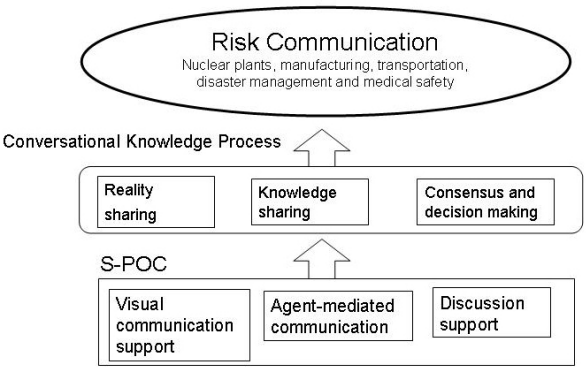

Fig. 11. The framework of SPOC.

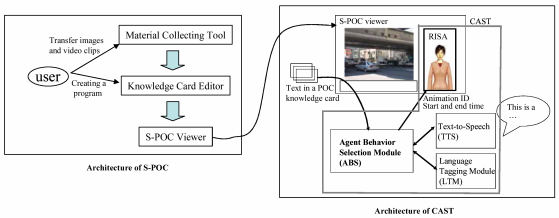

Fig. 12. RISA-CAST subsystem for generating ECA presentation.

5. SPOC

SPOC (Stream-oriented Public Opinion Channel) [6] was designed to serve as an integrated communication environment for a multi-faceted community activities such as risk communication. SPOC supports reality sharing based on visual images, knowledge sharing, and community-wide discussion for decision-making (Fig. 11).

The SPOC uses the POC system [7] as a knowledge sharing engine and extends it in several respects. First, SPOC allows for sophisticated presentation mechanism using an embodied conversational agent. Second, it supports video editing and presentation. Third, it allows a community discussion support system to be plugged in.

(1) The presentation mechanism using ECA

The RISA-CAST component allows for automatically generating from plain texts presentations featured with an animated agent (Fig.12). It selects and generates appropriate gestures and facial expressions for a human-like animated agent according to linguistic information in the text. An agent animation system called RISA can draw animations of natural human behaviors on web-based applications. The ECA subsystem called CAST (The Conversational Agent System for neTwork applications) generates agent's nonverbal behavior automatically according to rules based on theories of human communication and observation of human communicating behaviors (Table 2). The basic algorithm is extended that synchronization of verbal and nonverbal behaviors may be enhanced [8].

Table 2. Behavior selection rules.

Rule No.	Linguistic tag	Lemma example	Selected behavior
1	rheme & new		Iconic or beat gesture
2	demonstrative & interrogative	どのように (how), どんな (what) etc	Beat gesture
3	rheme & emphatic adverb	大変, 非常に (very, extremely) etc.	Beat gesture
4	rheme & demonstrative		Deictic gesture
5	rheme & new		Eyebrow raise
6	rheme & object & new		Head nod
7	end of utterance		Head nod
8	end of utterance		Blink
9	theme		Gaze away 70 % of the time
10	rheme & demonstrative		Gaze at
11	rheme		Gaze at 73 % of the time

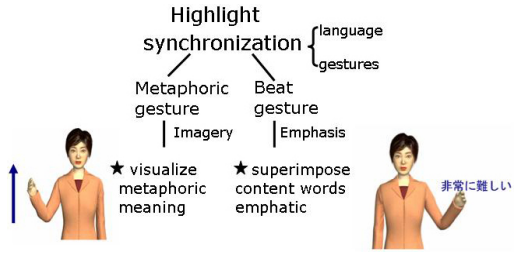

Fig. 13. Highlighting Synchronization of Verbal and Nonverbal aspects of presentation.

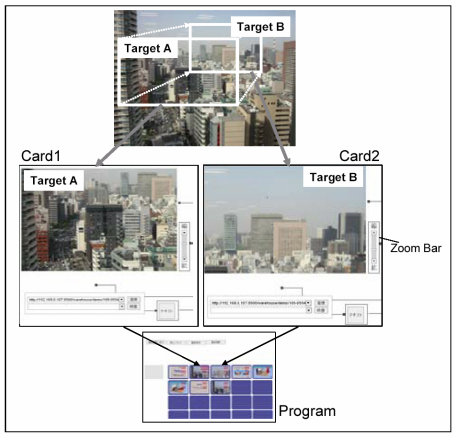

Fig. 14. The overview of the video editor.

(2) Video editing and presentation tools

The SPOC system allows for video presentation, using streamed video clips and camera works, such as zoom and pan, applied to graphic images. In order to help a casual users to create and review the video contents, the following tools are incorporated.

1. tools for collecting and accumulating materials (e.g. pictures, graphics and videos)
2. tools for creating video contents by assembling components of various kinds (Fig. 14)

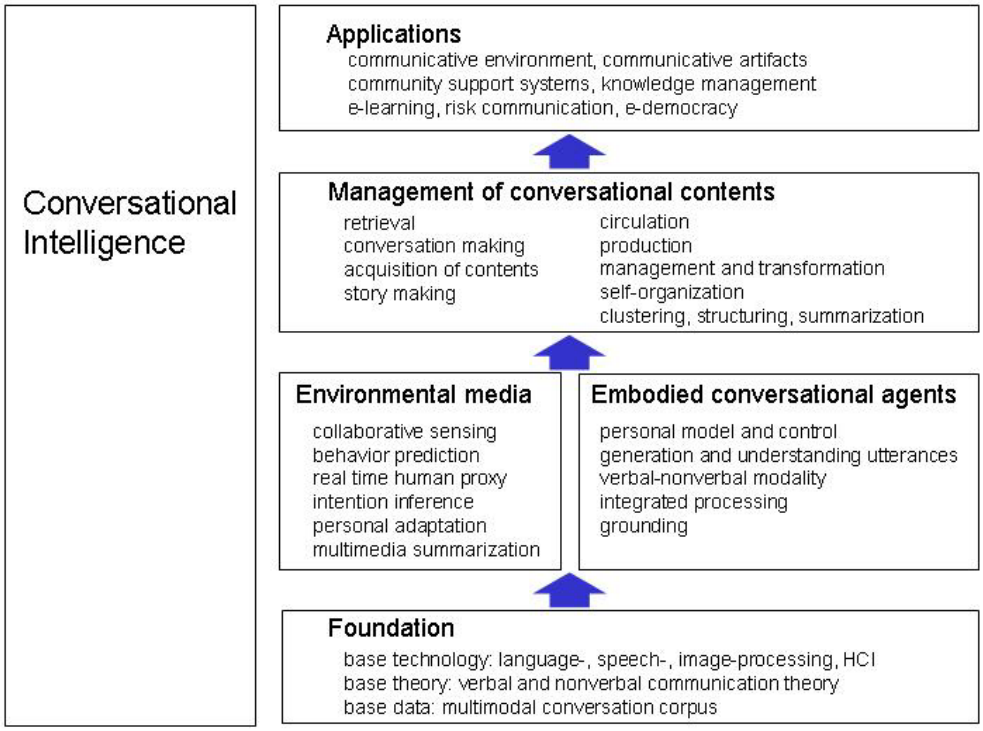

Fig. 15. The conceptual framework of research into conversational content.

3. a viewer for converting a knowledge card into a synchronized presentation with the ECA and multimedia materials.

(3) Discussion support system

SPOC allows CRANES (Coordinator for Rational Arguments through Nested Substantiation) [9] to be plugged in, which supports discussions in the community for consensus making. CRANES uses a probabilistic approach to selectively identify "stirring arguments" that stimulates the entire group processes. Two random-tree models are developed for the purpose of defining an indicator of noteworthiness. In the perfect random tree, the probability for a new comment to be associated with a certain existing node is assumed to be the same among all existing nodes. A biased random tree model is a more elaborate model that inflates the probability of the last node's producing a new child compared to other existing nodes. It reflects an intuition that when readers of a BBS consider which comment they respond to, they are more likely to choose the last node in the whole thread or those with some specific features. CRANES was applied to a community conflict over a regeneration scheme in London, to result in an augmented social construction of the conflict with multiple dimensions.

5. Towards Communicative Intelligence

A five-year research project "Intelligent Media Technology for Supporting Natural Communication between People" sponsored by Japan Society for the Promotion of Science (JSPS) addresses communicative intelligence as a generalization of the idea of communicative knowledge media. The term "communicative intelligence" reflects the idea of communicative intelligence implies a view that communication plays a critical role in both individual and collective intelligence. This project aims at establishing a technology for creating and utilizing conversational contents. It encompasses the environmental medium technology for embedding computational services in the environment, the embodied conversational agent technology for having computers interact with people in a social context, and the communication model of conversations that serves as a theoretical basis of system development (Fig. 15).

The environmental medium technology is based on the "making-computers-invisible" approach, aiming at embedding computers into the everyday environment so that they can assist people in pursuit for their goals without enforcing them to pay special attention to computer operations. It addresses cooperative intelligent activity sensors, automatic analysis of nonverbal communication with high-resolution scene analysis, personalization of environment medium, and intelligent editing of audio-visual streams.

A typical subject on the environmental medium technology is semi-automated tagging to videos using real time computer vision [10]. Basically, an intelligent video production system computes the best

matching between the given index-scenario and video stream captured by camera to produce an annotated video. The basic algorithm is scenario-speech matching where DP is used to calculate the best match between the given scenario and the sentences from a speech recognition system. The system also uses computer vision techniques to match the speech clues and motion cues for capturing basic behaviors such as pointing, holding out, manipulation, and illustration. Namely, the motion clue of pointing and holding-out is detected when the speaker's arm is stretched beyond the threshold. In contrast, there is no fixed pattern of manipulation or illustration. Currently, they are detected in a heuristic fashion by checking if the both hands are on or above the desk. In the vision system, information from various types of cameras is integrated to figure out the most plausible interpretation. For example, hand region is the intersection of the in-volume region, the moving region, the skin-temperature region and the skin-color region, while held-object region is the intersection of in-volume region, moving region, but not in the hand region.

The embodied conversational agent technology is based on the "making-computers-social-actors" approach, aiming at developing embodied conversational agents that can make conversation with people by following various social conventions. Embodied conversational agents are characterized as an interface between people and conversational content. We attempt at developing virtualized egos that can talk on behalf of the user, socially intelligent robots that facilitate conversations among people, and intelligent conversational content management systems by combining natural language processing and computer vision.

Research on the communication model of conversations aims at establishing a theoretical foundation of conversational content. We attempt at developing a unified model of verbal and nonverbal communication, a conversation corpus that accumulates conversation records with annotations to verbal and nonverbal events, and a method of analyzing conversation behaviors. A typical subject in this vein is analysis of the interactions of CMC. In [11], a model is proposed by applying the structural equation modeling to log data in 5748 message threads taken from 2channel with eight indices. It is suggested that the dynamism may be caused by three latent factors called specific expression, discussion type, and chitchat type.

6. Conclusion

In this paper, I presented information systems that help communities of people build and evolve collective knowledge. The future work include introducing advanced functions to universally support content production and entertainment computing that brings about user involvement.

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