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Intelligent and Responsive Spaces: Integrated Design of Ambient Physical Spaces and Information Spaces

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1. INTRODUCTION

Introducing information and communication technology already changed work processes and the content of work significantly. However, the design of work environments, especially physical work spaces such as offices and buildings, remained almost unchanged.

Neither new forms of organizations nor computer-supported work practices have been reflected in relevant and sufficient depth in the design of office space and building structures. In the future, work and cooperation in organizations will be characterized by a degree of dynamics, flexibility, and mobility that will go far beyond many of today's developments and examples. On demand and ad hoc formation of teams, virtual organizations, physically distributed and mobile workers are only initial examples of the work practices and organizational innovation to be expected. Contents and participants as well as contexts, tasks, processes and structures of collaboration will be changing frequently, in various ways and with an increasing rate of the innovation cycle. It is time to reflect these developments in the design of equally dynamic, flexible, and mobile work environments.

In this paper, we introduce the concepts of "Intelligent and Responsive Spaces(IRS)" and several "Interactive Work Components" and place them in the context of the integrated design of real and physical spaces, and virtual and digital information spaces. We also describe the current realization of IRS which includes all of the interactive work components.

The paper is organized as follows. First, we introduce the concept of Intelligent and Responsive Spaces(IRS) and describe three dimensions relevant for determining the scope of this concept. Second, we focus on the integrated design of the physical space and related information spaces. This includes the introduction of the "Interactive Work Components" concept and the so-called 2I-environments based on the requirements derived from three sample scenarios. The main part of the paper is then devoted to the IRS project, which is a three years research program carried out between 2005 and 2007 supported by KIST(Korea Institute of Science and Technology) and the presentation of the interactive work components we have developed. Finally, we put our work in perspective to related work and close with comments on future work.

2. INTELLIGENT AND RESPONSIVE SPACES

We propose the concept of an "Intelligent and Responsive Spaces(IRS)" as a flexible and dynamic environment that provides cooperative workspaces supporting and augmenting human communication and collaboration.

By the choice of this term we want to indicate that the building serves the purpose of cooperation and, at the same time, it is also cooperative towards its inhabitants and visitors. This is to say that the building does not only provide facilities but it can also (re)act on its own after having identified certain conditions.

According to our vision, it will diagnose problems, provide information, establish connections between people, and offer help. It will adapt to changing situations and provide context-sensitive information according to knowledge about past and current states or actions and, if available, about plans of the people. While the term spaces imply strong associations with a physical structure, our concept of a cooperative building goes beyond this.

It is our understanding that the "Intelligent and Responsive Spaces(IRS)" originates in the physical architectural space but it is complemented by components realized as objects and structures in virtual information spaces. Combining real and virtual worlds in a computer-augmented environment allows us to design enabling interfaces that build on the best affordances of everyday reality and virtuality.

As designers of human-computer interaction or rather human information interaction and human-human cooperation, we seek to use the best aspects of each. This perspective is inspired by related approaches in augmented reality[1], ubiquitous computing[2], and context awareness[3-5] described in the related work section.

We will provide examples of our realizations, e.g., in the IRS project in subsequent sections. A related aspect is that a cooperative building is not restricted to one physical location. Our perspective encompasses a distributed setting with remote locations where people work and dwell. The remote location might be an office building at another site of the organization or in a building at a client's site, a teleworker's small office at home or the temporary hotel room of a salesperson on the road.

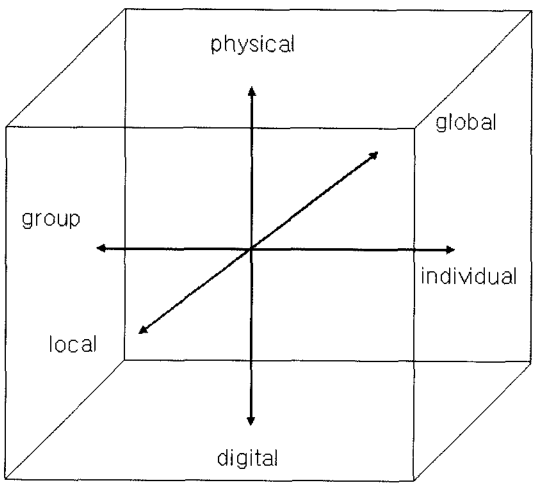

Figure 1 Three dimensions of intelligent and responsive spaces

Within the framework of a cooperative building, people can communicate, share information and work cooperatively independent of the physical location. In contrast to today's restricted desktop-based videoconferencing scenarios, we envision a seamless integration of information and communication technology in the respective local environment.

This results in more transparency and a direct and intuitive way of interaction, communication and cooperation in distributed environments. This approach builds on our earlier work on ubiquitous computing [2] and context awareness[5-7] is in line with the work conducted by my interaction and visualization group on Tangible Space Initiative in KIST(Korea Institute of Science and Technology).

For our thinking it was useful to distinguish the three dimensions shown in Figure 1. While each of these has been addressed before, the integrated global picture has still to be constructed. A central aspect is the real vs. virtual world dimension or, using a different terminology, the physical or architectural space vs. the digital information space or cyberspace. While each terminology has its own set of connotations, we will use them here more or less interchangeable.

Our day-to-day living and working environment is highly determined by the physical, architectural space around us constituted by buildings with walls, floors, ceilings, furniture, etc. They constitute also rich information spaces due to the inherent affordances either as direct information sources(e.g., calendars, maps, charts hanging on the walls, books and memos lying on the desks), or by providing ambient peripheral information(e.g., sounds of people passing by). With the advent of information technology the situation changed dramatically.

Information is a resource that is more and more available via the computer, usually the desktop computer. People tend to view information now as primarily available by diving into cyberspace. The situation changed not only in terms of having a different place or location for, in principle, the same information (e.g., on-line calendars, e-mail, electronic documents, on-line data bases) but - more important - in terms of new categories, constellations and ways of presenting information. Some of it has no counterpart anymore in the real physical world as, e.g., artificial worlds, virtual reality. Furthermore, in many cases it will be updated more often than other sources of information.

There is another aspect of the virtual part of this dimension. It refers to the situation where people are not in one physical location but in remote, distributed locations. Associated terms are virtual meetings, virtual teams, virtual organizations, but one has to note that the people, for example, of a virtual team, participating in a so-called virtual meeting are still real peoplel in real physical spaces. If one goes beyond standard desktop video conferencing, one is faced with challenging design issues for creating a shared background setting in which the distributed members are placed. This interpretation of virtual is, of course, closely related to the local vs. global context dimension. This dimension addresses the issue that we have to design the local environment with respect to the requirements resulting from its two roles. One role is to augment individual work and support group work in face-to-face meetings. The other is to provide an environment that facilitates the global cooperation of distributed people.

While there is an intuitive understanding of the meaning of local vs. global, one has to look at it in more detail. The term local is often used synonymous with co-located or same place. Think for example of a standard office or meeting room. But what is the scope of the same place? Is the hallway part of it when the door is open? Where are the boundaries? In contrast, where does a remote place begin? Is the meeting room on the next floor local because it is near by or a remote place? Does the notion of remote location and global context start in another building, another city or another continent?

In the IRS project, we will use sensors for determining users' position. Thus, the information devices know where they are, what their local and global context is, and the Intelligent and Responsive Spaces can be provided with information about the location of people in relationship to the devices. In IRS, we currently concentrate on the design of near by local environments, i.e. within one building, but we keep in mind that they will also serve as local counterparts for global cooperation. Each venue of a global distributed cooperation scenario has to offer much more than the current individual desktop office.

This implies that one has to look beyond desktops when designing this type of support. A third relevant distinction is based on the "individual vs. group dimension. It emphasizes that the type of support should be able to distinguish, for example, between different degrees of coupling shared workspaces. It should be possible to determine the degree of coupling by the users and provide awareness about who is sharing what and to which degree. This dimension reflects also the implications of different phases of team work: plenary presentation and discussion in the complete group, splitting up in subgroups, working individually on an assigned task, resuming again for the integration of ideas and merging of intermediary results, etc.

At a more general level, this dimension addresses the differences in social contexts of work arising from different organizational structures. In summary, it is our opinion that the realization of the "Intelligent and Responsive Spaces" has to pay attention to these three dimensions in order to constitute the basis for designing, using, and evaluating the workspaces of the future.

3. INTEGRATED DESIGN OF AMBIENT PHYSICAL SPACES AND INFORMATION SPACES

In our current work, we concentrate on two of the three dimensions discussed in the previous section: the real vs. virtual and the individual vs. group dimension. In order to develop a "Intelligent and Responsive Spaces" or parts of it, we follow a human-centered design approach.

The human is at the center of our considerations. However, the human is part of a group or a team and the team has to be viewed in the context of an organization. Combining this with the previous goal of an integrated design of the physical space and the information space, we arrive at the following four spaces (Figure 2) which need to be addressed in the overall

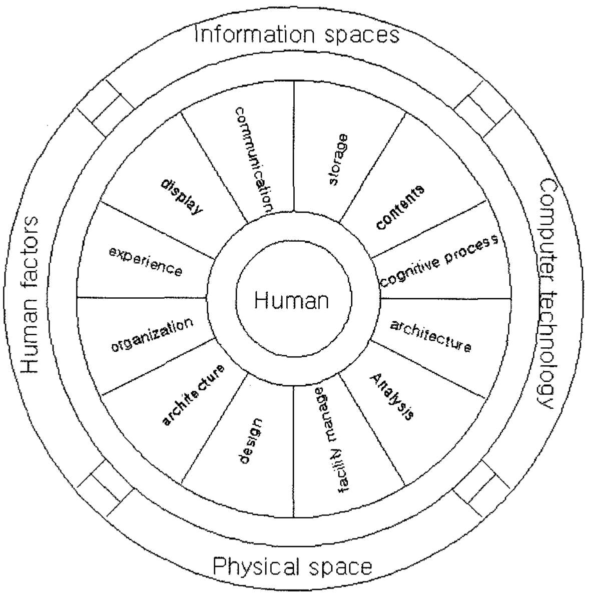

Figure 2 Integrated design spaces of Intelligent and Responsive Spaces

design: The cognitive space of the individual processing content in order to solve the tasks, the social space reflecting work practices and organizational context, the physical space including the architectural components of the building and the "Interactive Work Components", and the information space provided and mediated by networked information devices providing the functionality needed for working on the task.

Our design of the cooperative workspaces provided by a cooperative building is driven by example application scenarios but we are not limited to them. In the following, we describe scenarios, derive requirements and present proposals for design.

It is our vision of the workspaces of the future that the world around us is the interface to information (re)presented via ubiquitous devices, some of them visible, others "invisible" in the sense that they are embedded in the physical environment. We anticipate a situation, where we do not have to go to a specific place(e.g., the desktop computer in an assigned office) to interact with information and where people interact with each other mediated by digital information. Instead, ubiquitous and interactive landscapes for interaction and cooperation augment our reality.

3.1 The Concept of Interactive Work Components

Inspired by previous work on augmented reality and ubiquitous computing and our own work on electronic meeting rooms, we describe now two application scenarios which served as starting points for our "Interactive Work Components" concept. Scenario One: A meeting in the hallway. Meeting a colleague by chance in the hallway and starting a discussion might result in the intention to explain something by drawing a sketch on the wall and annotate it by scribbles. Besides the fact that this is usually not accepted in our office buildings, in current buildings with existing technology one could not store and later modify these elements of the discussion. It is also not possible to search for related information in a background information base and to link this information to the sketch and the scribbles on the wall. When the two are finished, the result of the work should disappear from the wall but still be accessible at any other place in and also outside the building. In the future, we like to be able to turn to the wall and do just this. Think of the wall as an interactive wall or as one being "covered" by high resolution electronic wallpaper providing the functionality needed and being networked to other places. Scenario Two: Dynamic team rooms. In typical team work, a team meets and often divides up the work by assigning subtasks, then breaks up so that individuals and subgroups can go off to do their work. After some time, perhaps the next day, the full team meets again and discusses the results which form the basis for the next phase of cooperation. In a time-critical situation, it would be very useful if one can reduce this cycle time of full team meeting/subgroup meetings. An alternative is to provide ways for subgroups to split up during the meeting in the same room, do their work, rejoin and then immediately merge the results. Providing adequate information technology support for this scenario requires a team or project room which is equipped with components and resources which are very flexible so that they can be reconfigured dynamically and on-demand in order to meet the requirements of changing team work situations. Our analysis of this scenario includes a plenary situation and different subgroup or individual work constellations. The plenary is characterized by the full team sitting in chairs and facing a large public display. An example of subgroup work is that people move their chairs and group them in one corner of the room, discuss their task and exchange ideas. Another subgroup walks over to an ad-hoc meeting table, stands around it, views and edits tables and diagrams. A third constellation is that people walk up to a whiteboard at the wall, draw sketches and annotate them with scribbles. Of course, it might be the case that some of these "subgroups" consist only of one person using the devices for individual work. It is our vision that the chairs, the table, and the wall are interactive devices providing support for these cooperation and interaction situations via embedded information technology. Our approach to meet the requirements of these scenarios is based on the "Interactive Work Components" concept. By "Interactive Work Components" we mean computer-augmented things resulting from the integration of room elements(e.g., walls, doors, furniture like tables, chairs, etc.) with computer-based information devices. The resulting "Interactive Work Components" components are interactive. They provide support for the creation, editing, and presentation of information. They are networked and therefore have access to worldwide information. The chairs and the table are also mobile due to wireless networks and stand-alone power supply. The general goal of developing "Interactive Work Components" is to make progress towards the integration of architectural spaces and information spaces. In the context of CSCW, we have a specific goal, i.e. to develop reusable components which can be tailored and composed to form flexible and dynamic "cooperation landscapes" serving multiple purposes: team or project rooms, presentation suites, information foyers, etc. Both goals have in common that we also have to develop new forms of human-computer interaction for multi-user, multiple-displays environments. In section 4, we describe the initial set of "Interactive Work Components" components we develop in the IRS project. It consists of an interactive electronic wall screen(Workscreen), an interactive table(Workbench), and mobile and networked chairs with integrated slate computers(Interacchairs).

3.2 The 2I Environments

In our discussion of the local vs. global dimension, we raised the issue of identifying and locating devices in buildings and in global distributed environments. Using sensors, one can acquire information on who(people, interactive work components) is located where, connected with whom and interacting with whom. This can be used to structure the cooperation process among people and to provide the corresponding means and information needed by an individual or a team. The next scenario illustrates part of this idea. Scenario Three: The room that knows you and your team. A project team enters the room. The room senses the members of the team, compares this list to previous users of the room, and identifies the team and the project discussed at the last meeting. If the team wants to, the room configures itself restoring the state of the last meeting including the set of documents they were working on before. The content and the structure of the information are displayed again on the different Interactive Work Components(e.g., the interactive wall, the interactive table). Thus, the team can continue right where they were at the end of the last meeting. A generalization of this idea results in what we call Intelligent and Interactive rooms or environments(2I-environments). "Intelligent" means that the environment is able to observe a room, a hallway or another area of the building it is assigned to. It will be able to identify and locate people by various means(e.g., active badges, image recognition, video analysis). The same is possible for tagged and/or networked devices, e.g., the Interactive Work Components. Being informed about who and what is where and what is going on, the 2I-environment can be active by (re)acting in correspondence with predefined rules, e.g., providing information that there is a prepared agenda for the current meeting, that a team member who attended the last meeting is not present, etc. Furthermore, it can be "Interactive" by configuring the whole room or part of it according to context information on what the room should be used for, e.g., displaying the work environment of a specific project team. A3-environments are adaptive in the sense of auto configuration but they can also be adapted by the user or the team. In both cases, the same room(or hallway, foyer, etc.) can be orchestrated for multiple purposes providing interactive information landscapes for changing usage conditions.

4. IRS: AN INTELLIGENT AND RESPONSIVE SPACES FOR CREATIVE COLLABORATIVE WORK

In order to test the feasibility of the concept of a "Intelligent and Responsive Spaces", the IRS project was initiated. Its overall goal is to develop a work and collaboration environment which responds to the demands of new work practices and organizational innovation as they are characteristic for ad hoc and on demand teams, multiple-purpose use of project-team rooms, etc.

Besides the overall goal IRS serves as a test-bed for the development of several interactive components and 2I-environments and their tailor-ability to specific requirements of potential user groups. It will also provide the basis for evaluating the ideas and concepts by applying them to a specific application scenario, i.e. the support of so-called creative teams. Examples are teams designing a new product, developing a marketing strategy for an existing product, developing a perspective on the future strategy of a company, etc.

4.1 Motivation and Requirements

The importance of supporting different work phases, e.g., involving subgroups as in the second scenario, has been shown in several empirical studies we conducted to evaluate our meeting support systems[5,6]. We investigated the role of different personal and public information devices(networked computers, interactive whiteboard) and different combinations of them for meeting room collaboration in a recent empirical study[7]. The results show that the groups which developed a balanced proportion of individual work, subgroup activities, and full team work achieved better results than those groups which stayed most of the time in the full-team work configuration. The degree of flexibility to work in different modes was largely determined by the combination of information devices provided to the team. Offering a wider range of devices or interactive components resulted in more flexibility.

While these encouraging results were obtained in existing electronic meeting rooms, these constellations do not provide the necessary flexibility of assigning different physical workspaces within a meeting room to subgroups and individuals. Existing electronic meeting rooms usually employ one large static table and computers on top of it or mounted in the table as we also did in the past. Thus, it is not possible to allocate and (re)configure the resources in terms of information objects/spaces, interactive components in a flexible way. This flexibility is a design goal of high priority for the IRS environment.

This design goal also requires to develop new means of distinguishing between individual and (sub)group work modes and using the detection of behavior and actions in the real world instead of setting parameters via complicated interfaces for initiating and terminating computer-supported cooperation(e.g., sharing of information) between people. The spatial flexibility and mobility of the "Interactive Work Components" requires the use of wireless networks for connecting the information devices embedded in the room and in the furniture and an independent power supply. The current application scenario for IRS is to serve as a collaborative work environment facilitating especially creativity and innovation processes in teams.

In order to inform our design and to tailor the generic components to this purpose, we are investigating specific requirements in terms of appropriate "Interactive Work Components" and creativity techniques supporting these processes. To this end, we are conducting an empirical study involving interviews and brainstorming of different project members in selected teams of Intelligence and Interaction Research Center in Korea Institute of Science and Technology(KIST). These teams are also concerned with product design, marketing campaigns, strategic future planning, etc. We are describing and analyzing their current work practices using existing rooms, furniture, equipment, and creativity techniques. On this basis, we identify shortcomings of conventional practices and equipments. Furthermore, we are interviewing these teams about their requirements for support of creative collaborative work in the near future but inquire also about their fantasies and visions for the far future.

4.2 Interactive Work Components of IRS Environments

We defined an initial set of "Interactive Work Components" which will be described in detail in the following subsections:

- Workscreen – an interactive electronic wall
- Workbench – an interactive table
- Interacchairs – mobile and networked chairs with integrated interactive devices

In addition, to bridge or to interact between interactive components above and human, we are designing a mechanism so-called Mime(Multipurpose interaction method extensions).

While each category of the "Interactive Work Components" has a value of its own, the full benefit will only be available in their integration and combined use corresponding to the different work phases identified before. This is achieved via the integration of the "Interactive Work Components" in an application, in this case the IRS scenario. The technical integration is achieved by employing wireless networks connecting all components as well as by client-server software based on the cooperative IRS framework. Figure 3 shows our plan for the IRS environment. The "Interactive Work Components" of IRS have been or are being built. The software providing the required functionality is still under development. Therefore, one has to keep in mind, that not all features described are already implemented in full but are part of the concept and the requirements for the components.

Figure 3 Photo views of IRS environments

4.3 Interactive Workscreen

Project teams in so-called project rooms often use large areas of assembled sheets of paper(usually covering the walls) to create and organize their information. Examples are large project overviews in terms of its parts, their relationships and dependencies. However, the need for large visual areas is not restricted to the organizational aspect. In many cases, even more important is the possibility for displaying, annotating and editing large contents which is not without problems, especially in the paper-based situation.

Display space on paper or via an electronic information device is a crucial point for most visually-oriented tasks. Furthermore, in the electronic version the requirement is to be able to interact with the content in a very intuitive way relying on standard gestures known from the interaction with the physical objects in the real / paper world.

The objective of the Workscreen is to represent a computer-based device that serves these needs. It can be considered an "interactive electronic wall" represented by a touch-sensitive information device. The current realization of interactive wall uses laser sensor and motor driven driving gear with bidirectional rotation to recognize the user's gesture based input on the wall or screen, and the interactive wall is installed with three front-projections and a interactive LCD screen with display size of 55 inch and a resolution of 1920 by 1080 pixels. It fills whole side of the room completely(see Figure 4).

The Workscreen enables groups like project teams to display and to interact with large information structures collaboratively. The goal is to support two or more persons, either individually, in parallel or sharing the whole display space. The size of the Workscreen creates a new set of problems for human-computer interaction. It should be possible that information objects can be taken at one position and put somewhere else on the display or thrown from one side to the opposite side. Dialog boxes always should appear in front of the current user(s). User interface components should always be at hand, etc.

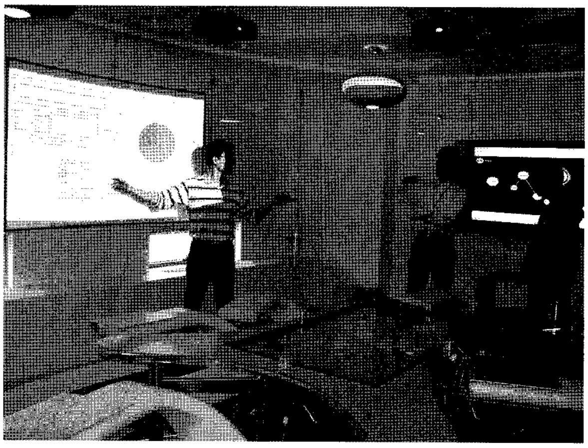

Figure 4 Muti-user interaction in front of Workscreen

4.4 Interactive Workbench

The Interactive Workbench is the first in a series of information devices that investigates general shapes and orientations of interaction areas. It is designed for display, discussion, and annotation of information objects by a group of two to six people sitting or standing around the table.

The current stand-up version of the Workbench (Figure 5) is built as a horizontal table with LCD unit with a touch-sensitive display surface. Inside the table, an LCD beamer projects a high-resolution image of 1920×1080 pixels to the top of the table. The integrated wireless and wired network provides the Workbench with a high degree of flexibility.

Since a round or oval-type display has no selected orientation as, e.g., top and bottom and left and right at the desktop computer, one has to provide new means of interaction. Information objects displayed on the table have to be rotated and shuffled across the surface in correspondence to different view perspectives of the users standing or sitting around the table. Manipulation is done by gestures using fingers or pens, annotations by voice and/or pen. In addition, a virtual screen keyboard is available for more extensive text-entry tasks.

Figure 6 Interactive chairs and their usage around workbench

4.5 Interactive Chairs

The Interacchairs(see Figure 6) represent a new type of furniture. They combine the mobility and the comfort of armchairs with high-end information technology. So far, we developed an integrated information device with a docking facility for plugging in laptops or other mobile computers carried along (Figure 7). Each chair is provided with an interface for wireless networks and an independent power supply for maximum flexibility and mobility.

Figure 5 Informal and natural discussion at the Workbench

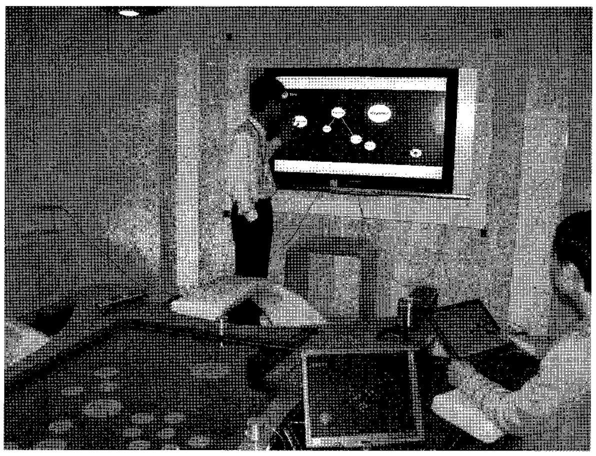

Figure 7 Interactive chair with docking facility for standard laptops

We use a wireless network for connecting to the Ethernet. Because of this connection, one can access world-wide information while sitting in the chair. Furthermore, the chairs enable people to make private annotations and notes and to connect to shared workspaces, displayed on devices like the Workscreen or the interactive wall and Workbench. Users can edit and annotate objects displayed on these interactive components not only locally but also remotely.

Localization of the chairs in a room and the identification of the person sitting in the chair will be done automatically based on sensors we will provide in the room. This allows to bring up and configure the personalized environment. Furthermore, this enables also to establish network connections and then shared information displays simply by moving chairs together. Built-in audio and video communication facilities, leaving messages for other people sitting in that chair as well as tactile notification of incoming calls/information are further aspects that are planned in this part of the IRS project.

4.6 Mime(Multipurpose interaction method extensions)

Our new mechanism to interact between human and computer is inspired by pantomimic gestures: These are the gestures typically used in showing the use of movement of some invisible tool or object in the speaker's hand. When a speaker says "I turned the steering wheel hard to the left", while mimicking the action of turning a wheel with both hands, they are making a pantomimic gesture.

The interpretation of shape-related(iconic) gestures rests upon the basic assumption that iconic gestures are similar to the referent they describe. In contrast to most gesture recognition approaches which directly map a gesture expression onto meaning, our model decomposes meaningful upper limb movements into shape properties. These properties represent an abstract geometrical description of the gesture that is independent from a particular realization. The property "roundness", for example, may be indicated with the thumb and index finger shaping an "O", or with the index finger tip moving on a circular trajectory.

The geometrical gesture model can then be matched against a set of object models to determine the most

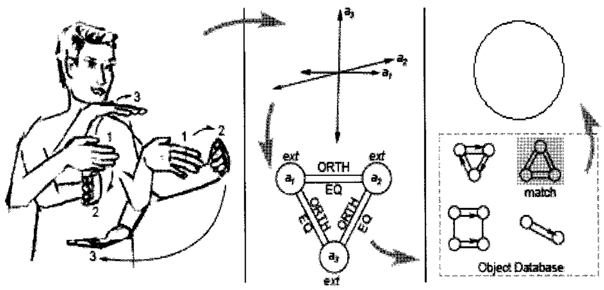

Figure 8 Interpretation of a complex iconic gesture

similar object(Figure. 8). The gesture/object model is internally represented as a graph in which nodes represent shape properties and links spatial relations. The detection of similarity is performed by subgraph matching. With this approach, the decomposition of meaning is not limited to a single gesture. Properties may accumulate over a series of movements and postures as shown in the example(Figure 8) where the idea of a cube is expressed in three gesture phases.

5. RELATED WORK

The development of different interactive components as instantiations of this concept and their integration in the IRS environment is related to and was inspired by different developments in human-computer interaction and computer-supported cooperative work. The most relevant examples are Tangible Space Initiative, ubiquitous computing, and collaborative workspaces, in particular meeting support systems. One perspective is that we develop new ideas for human-computer interaction and apply them to the design of collaborative work environments. A complementary perspective is that we extend interaction techniques by cooperative functionality in order to develop ubiquitous and collaborative workspaces.

Pursuing the approach of Tangible Space Initiative seriously implies to have many, loosely spread and networked information devices around, with displays of different sizes, instead of a (central) desktop computer. This is the concept of ubiquitous computing (Weiser, 1991, 1993). Some of the devices will stand out and be recognized as computers, others will be "invisible" as they are embedded in the environment. Our approach concentrates especially on integrated devices that are embedded in furniture, like chairs and tables, as well as in architectural elements of buildings, such as doors or walls. Once the physical space is filled with multiple devices, the issue arises on how to transfer information between them in an intuitive and direct way and, more general, how to interact with them.

With respect to existing work in computer-supported cooperative work, especially meeting support systems is a new approach because of the notion of dynamic offices and mobile interactive components. This allows flexible and dynamic creation and allocation of work-spaces in different parts of a room in correspondence with the current mode of the group activity instead of having a fixed setup of chairs around a static table. It enables new methods of establishing cooperation and sharing of information, e.g., by simply moving chairs in close spatial proximity in order to form a subgroup.

Thus, initiating cooperation between two or more people can be based on an intuitive and natural physical movement instead of selecting parameters in a number of menus and dialogue boxes. Other relationships concern the type of work supported and the type of software used for this support. With respect to supporting creative work, the most common technique is brainstorming. It has been demonstrated that computer-supported brainstorming results in more number of ideas than verbal brainstorming.

There are limitations with existing systems we like to overcome. We will provide a suite of creativity techniques which can be combined in a flexible and seamless way. Furthermore, existing systems are usually limited to text items. Another issue is the flexibility of the available structures in order to overcome the limitations of more or less flat or hierarchical list structures. This will be partially based on our previous work by using hypermedia structures for the underlying representation.

6. CONCLUSION AND FUTURE WORK

We have presented a comprehensive approach for the integrated design of real physical spaces and information spaces. The central idea is the concept of "interactive work components" facilitating interactive and cooperative functionality at every place in a "Interactive and Responsive Spaces. This paper described the current state of the design considerations, the first realization of interactive components and the requirements for the software currently under development. Since the described components of IRS introduce new, to some degree unfamiliar forms of human-computer interaction, there is a need to evaluate their usefulness and their usability in a systematic fashion. Since IRS offers various configurations and combinations of the components, we have to evaluate also how to match different cooperation scenarios with different configurations and to investigate their influence on the work processes. This evaluation effort is an important aspect of our iterative design cycle.

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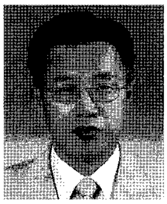

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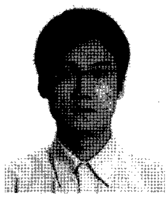

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