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[1]In the Esprit EuroCODE project, Ellen Christiansen, Mike Robinson, and I have worked to characterize shared material and common artifact in terms of activity theory.

Structuring the Field of HCI: An Empirical Study of Experts' Representations

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Abstract. This paper presents the results of empirical study of mental representations of the field of HCI, obtained by statistical analysis. Eight HCI experts participating in the study were asked to classify the papers presented at the EWHCI'92 Conference. The results show satisfactory agreement between the experts' classifications, as well as high interpretability of the group data. Some conclusions about the implicit "cognitive map" of the HCI field are discussed in the paper.

1 Introduction

Probably the most salient feature of Human Computer Interaction (HCI) as a field of research and practice is its interdisciplinary nature. Specialists with very different backgrounds -- psychologists, computer scientists, linguists, etc., work together while solving all kinds of problems related to design, evaluation, and analysis of computer systems. This interdisciplinarity of HCI field is inevitable and is potentially beneficial, since it provides an opportunity to exchange ideas between various paradigms. At the same time, however, it raises the serious problem of creating a common conceptual system which is necessary for any cooperation to be productive. This problem manifests itself in various forms and in various ways.

First, the very status of HCI as a field of study is discussed (see [1, 10]). The major questions of this discussion are: Is HCI a separate discipline? What kind of cooperation between constituent disciplines is possible and desirable? There are different answers to these questions -- from denying the value of any (premature) attempts to reach interdisciplinarity in HCI, through claims to establish separate links between pairs of disciplines, to call for an integrative perspective.

Second, if HCI is a special discipline, then it needs an appropriate theoretical basis. The role of theory in HCI is also under debates. The influential book "Designing Interaction: Psychology at the Human Computer Interface" [3] and the proceedings of the recent conference INTERCHI'93 (see [8]) reflect various points of view on this problem.

Third, the problem of interdisciplinarity is also discussed in studies of cross cultural aspects of HCI. Many specialists emphasize the existence of at least two cultures in HCI community [4]: the technology-oriented and the human-oriented.

In the present paper we also address the problem of an overarching conceptual scheme that could serve as a coherent basis for interdisciplinary studies in the field of HCI. However, we try to approach this problem in an empirical way. The basic assumption underlying the present study is that experts have an implicit representation of the HCI domain which makes it possible for them to coordinate their actual activities while conducting interdisciplinary projects. Our idea was to reveal this representation in a situation which require the "externalization" of the implicit "cognitive map" through structuring various items related to different aspects of HCI.

The last year East-West Conference on Human-Computer Interaction held in St.-Petersburg (EWHCI'92) provided very good opportunity for conducting such a study. First, a lot of world famous experts in the field of HCI attended the conference and it was possible to use some of them as experts in our study. Second, "ecologically valid" tasks for HCI experts were discovered in the process of composing the EWHCI'92 scientific programme. Several members of the scientific programme team came up with different versions of the programme. It seemed that the process of structuring the selected papers into appropriate sections was considered by HCI people as a meaningful kind of activity. At the same time there was a remarkable agreement among those involved on what is the general structure of the field.

Below is a description of an empirical study conducted during the EWHCI'92 conference [6] and aimed at revealing the implicit representation of the field of HCI in a sample of internationally recognized experts.

2 Method

Subjects. Eight international HCI experts participating in the EWHCI'92 Conference served as subjects in the study. Seven experts were from the West, and one expert was a Ukrainian scientist with experience of working in both Eastern and Western institutions.

Data collection. Data was gathered interactively using ExSort, a multiple expert knowledge acquisition tool for classification problems [2]. This program collects data using the free sorting technique [9] and then performs hierarchical cluster analysis of two-way similarity matrix according to Johnson's algorithm [7]. The free sorting procedure consists of dividing a card pack, where each card is labeled by some concept name, into smaller piles that represent similarity classes. The number of these piles and their nature are not predefined, so the expert is free to determine the total number of piles and in choosing principles of classification. This procedure results in a symmetrical matrix $\{a_{ij}\}$, where $a_{ij}=a_{ji}=1$ if the ith and jth items have been placed into the same pile, and $a_{ij}=a_{ji}=0$ otherwise. After N experts have proposed their different sorts, the measure of proximity between stimuli i and j could then be calculated:

$$\delta_{ij} = \sum_{k=1}^{N} a_{ij} / N$$

The proximity matrix $\{d_{ij}\}$ can undergo cluster analysis to obtain a hierarchical representation of data structure.

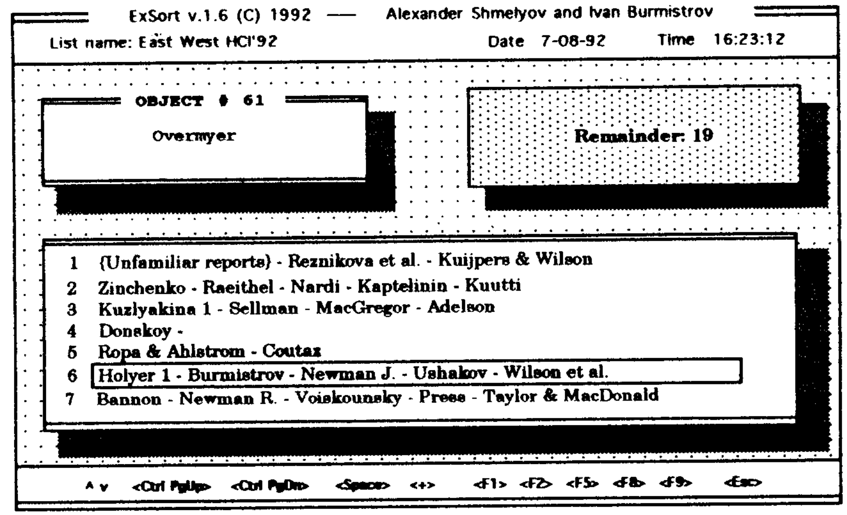

Fig. 1. ExSort: data gathering tool.

Dear Colleague,

We are carrying out an empirical study of the HCI field. In this study, we use the reports presented at EWHCI'92 as the stimuli, and ask HCI experts to classify conference reports according to possible similarities among their approaches and topics.

The goals of our study are the following:

(1) To elicit expert knowledge about the HCI field in order to outline main subareas of the HCI field, which is still rather fuzzy and ill-structured.

(2) On the basis of expert knowledge extracted, to provide future EWHCI'93 Organizing Committee with a conceptual map that would help the Committee to arrange reports within parallel sessions.

(3) To detect the "mainstream" reports and those reports which are marginal to the main focus of HCI.

(4) To determine the level of interests' overlap between Eastern and Western participants and to outline possible ways for further integration.

You will perform the computerized classification task based on free sorting technique. We suppose that your participation in our study would take you about one hour at most.

Thank you in advance.

Fig. 2. The introductory instruction for experts.

A screen dump for the sorting process is shown in Figure 1. The program makes use simple animation to simulate the sequential extraction of objects from the pack placed at the upper right corner of the screen. Then the current card (item) moves to the upper left corner, and the expert has to place it into one of the existing classes or create a new class if current item cannot be placed into any existing class. Classes are listed at the scrollable window at the bottom half of the screen. The subject uses cursor keys to choose an appropriate class, and as s/he does so, the current card "falls" into the class chosen. Additional ExSort facilities make it possible to return an already classified item back to the pack or disband a whole class of items.

The items presented to experts in our study were names of EWHCI'92 participants accompanied by the titles of their papers. Both verbal presentations and posters were included (79 papers in total).

The subjects were informed of the goals of the study (see Figure 2) and the operational instruction included in the on-line session as the ExSort help screen. Then experts proposed their classifications interacting with the program.

3 Results

The hierarchical cluster tree provided by ExSort is shown in Figure 3. The half-split analysis showed satisfactory concordance in experts' classifications.

```
Cluster 1 _____________________________ Cl. 1.1 ____ Cl. 1.1.1
(1) AT ZINCHENKO Activity Theory            (1)          (1)
(2) AT RAEITHEL Activity theory             (2)          (2)
             and cooperative work           (3)          (3)
(3) AT NARDI Approaches to studying context (4)          (4)
(4) AT KAPTELININ Activity theory and HCI   (5)          (5)
(5) AT KUUTTI Activity theory and HCI
```

Fig. 3. The cluster tree for EWHCI'92 reports (to be continued).
Author names are accompanied with brief topic descriptions. Abbreviations that follow numbers of papers correspond to following sessions within the EWHCI'92 Conference programme:

AT	Activity Theory and HCI	KD	Knowledge and Data Based Systems
GP	General Principles of HCI	ED	Education
CW	Computer Mediated Communication and Collaborative Work	RE	Requirements and Evaluation
GI	Graphical Interfaces	CL	Computer Assisted Learning
MO	HCI Models	ID	User Interface Design
HM	Hypertext and Hypermedia	FU	Future of HCI
DM	Design Methodologies	P*	Demonstrations and Posters
PS	Psychological Perspectives		


```
Cluster 2 ______________________________________ Cl. 2.1 __ Cl.2.1.1
(1) DM UZILEVSKY ea Ergosemiotical approach    |  (2)     |  (2)
(2) GP BARNARD ea Framework for modelling HCI  |  (3)     |  (4)
(3) MO USHAKOV Models and standards            |  (4)     |
(4) MO WILSON ea. Modelling perspectives       |          |_ Cl.2.1.2
(5) GP SINGLEY ea. Theory development          |             (3)
               and design evaluation           |_ Cl. 2.2
                                               |   (1)
                                               |_ Cl. 2.3
                                                   (5)
```

```
Cluster 3 _____________________________________ Cl. 3.1 __ Cl.3.1.1
(1) CW BANNON From HCI and CMC to CSCW            (1)   |  (4)
(2) CW NEWMAN R. Collaborative writing            (2)   |  (5)
(3) CW VOISKOUNSKY Speech in CMC                  (3)   |
(4) CW MATSUURA ea. Interactions in virtual       (4)   |_ Cl.3.1.2
                    environment                   (5)      (1)
(5) CW BELYAEVA ea. Telecommunication             (6)      (2)
                    environment                   (7)      (3)
(6) CW PRESS Participation in CSCW systems                 (6)
(7) PS TAYLOR ea. CMC: group salience and                  (7)
                  individual identifiability
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```
Cluster 4 _____________________________________ Cl. 5.1 __ Cl.5.1.1
(1) HM INSTONE ea. Information retrieval from      (1)   |   (5)
                   hypertext                       (2)   |   (8)
(2) HM DOBRINEVSKI HCI in hypertext systems        (3)   |
(3) HM MCKERLIE ea. Hypermedia effect              (4)   |
(4) HM DOBRINEVSKI ea. Integrated hypertext        (5)   |_ Cl.5.1.2
                       software                    (6)   |   (1)
(5) HM PEMBERTON ea. Hypertext design tool         (7)   |   (2)
(6) HM LAKAYEV ea. Hypertext structural analysis   (8)   |   (3)
(7) HM BERND Graph model of hypertext querying     (9)   |   (4)
(8) P* SIDOROV Hypermedia tool for information           |   (6)
              integration                                |   (7)
(9) P* CRECHMAN ea. Knowledge representation in          |
                    hypertext                            |_ Cl.5.1.3
                                                             (9)
```

Fig. 3. The cluster tree for EWHCI'92 reports (continued).

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  Cluster 5  ________________________________  Cl. 4.1 __ Cl.4.1.1
(1) GI AVERBUKH ea. Visual programming           |  (1)  |    (1)
                   representations               |  (3)  |
(2) GI GAVRILOVA ea. Cognitive GUI               |  (4)  |_ Cl.4.1.2
(3) GI LIEBERMAN Visual programming by example   |       |    (3)
(4) GI BRUSILOVSKY Adaptive visualization in CAL |       |_ Cl.4.1.3
                                                 |            (4)
                                                 |_ Cl. 4.2
                                                      (2)
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```
  Cluster 6  ________________________________  Cl. 6.1 __ Cl.6.1.1
(1) DM LIM ea. Human factors in system          (1)    |    (1)
        development                             (2)    |    (2)
(2) DM WAGNER Design methodology for HCI        (3)    |    (3)
(3) DM FLOYD ea. Framework for cooperative      (4)    |
        software development                    (5)    |
(4) RE OVERMYER Specifying requirements with           |_ Cl. 6.1.2
        multimedia                                     |    (4)
(5) GP BASS ea. Reference model for system             |        |
        construction                                   |_ Cl. 6.1.3
                                                            (5)
```

```
  Cluster 7  ________________________________  Cl. 7.1 __ Cl. 7.1.1
(1) PS MORGAN ea. Gender differences and        (1)    |    (1)
        cognitive style                         (2)    |
(2) PS CONWAY Colour naming models                     |_ Cl. 7.1.1
                                                            (2)
```

```
  Cluster 8  ________________________________  Cl. 8.1 __ Cl. 8.1.1
(1) KD SVIRIDENKO Knowledge structuring       |   (1)  |    (1)
        environment                           |   (2)  |    (4)
(2) KD BREZILLON Building explanations        |   (4)  |
(3) KD DOLMATOVA Design of domain models      |        |
(4) KD KUIJPERS ea. Multi-modal interface     |        |_ Cl. 8.1.2
                                              |             (2)
                                              |_ Cl. 8.2
                                                  (3)
```

Fig. 3. The cluster tree for EWHCI'92 reports (continued).


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  Cluster 9  ________________________________  Cl.9.1
(1) KD SUN ea. Relational databases           |   (1)
(2) KD POPOV ea. Dynamic query refinement     |_ Cl.9.2
(3) P* MULDERS ea. Document retrieval         |   (2)
                                              |_ Cl.9.3
                                                  (3)
```

```
  Cluster 10  _______________________________  Cl.10.1 __ Cl.10.1.1
(1) CL KUZLYAKINA System LECAT                |   (1)   |    (1)
(2) CL SELLMAN System "Gravitas"              |   (2)   |    (2)
(3) CL REZNIKOVA ea. "Japanese writing"       |   (3)   |    (3)
        courseware                            |   (4)   |
(4) CL MACGREGOR Music compositional          |         |_ Cl.10.1.2
        software                              |              (4)
(5) ED COULOURIS ea. Teaching application     |
        design                                |_ Cl.10.2 __ Cl.10.2.1
(6) ED GYGLAVY Information technologies       |   (5)   |    (5)
        for teenagers                         |   (6)   |_ Cl.10.2.2
(7) ED ADELSON Scientific inquiry skills      |              (6)
(8) RE DAIBOV ea. Interface educational       |_ Cl.10.3
        component                             |   (7)
(9) P* GRABILINA ea. Training program         |
               development system             |_ Cl.10.4
                                              |   (8)
                                              |
                                              |_ Cl.10.5
                                                  (9)
```

```
  Cluster 11  _______________________________  Cl.11.1
(1) ID DONSKOY Object oriented graphic editing  |  (1)
(2) ID ROPA ea. Video viewer interface          |_ Cl.11.2
                                                    (2)
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```
  Cluster 12  _______________________________  Cl.12.1
(1) ID HOLYER 1 Object-based user interface     |  (1)
(2) PS BURMISTROV Object oriented user interface |_ Cl.12.2
(3) P* BOEVE Edit paradigm for HCI              |  (2)
                                                |_ Cl.12.3
                                                    (3)
```

Fig. 3. The cluster tree for EWHCI'92 reports (continued).

```
 Cluster 13 ____________________________ Cl.13.1 ___ Cl.13.1.1
(1) PS NEWMAN J. User agent design      |    (2)   - |     (2)
(2) FU MOUNTFORD Movie interface        |    (3)     |_ Cl.13.1.2
(3) P* HOWELL ea.1 Multimedia           |    (4)     |     (3)
               information bases        |            |_ Cl.13.1.3
(4) P* HOWELL ea.2 Multimedia           |                  (4)
              property information      |_ Cl.13.2
                                             (1)

 Cluster 14 ___________________________________________ Cl.14.1
(1) P* GAVRILIN ea. Psychoemotional conditions        |   (1)
(2) P* KALINKIN ea. Stimulating exercises.            |_ Cl.14.2
                                                          (2)

 Cluster 15 ___________________________________________ Cl.15.1
(1) P* HOLYER 2  User interface design environment |     (1)
(2) P* ZABOTIN ea. Flowchart based visual           |_ Cl.15.2
                programming                               (2)

 Cluster 16 ___________________________________________ Cl.16.1
(1) P* TCHEBRAKOV ea. 1 Linear regression           |     (1)
(2) P* TCHEBRAKOV ea. 2 Data analysis               |_ Cl.16.2
                                                          (2)
```

Cluster 17 ID SOYGHIN User interface in computer modelling

Cluster 18 MO SKORODUMOV Fractal approach

Cluster 19 GI PETRE & PRICE Text and graphics in user interfaces

Cluster 20 GI COUTAZ Taxonomy of multimedia and multimodal UI

Cluster 21 ID SCOWN Real-time issues in multi-agent systems

Cluster 22 PS CHEMERIS ea Human factors in ELOIS system

Cluster 23 P* KUZLYAKINA 2 Parametric synthesis

Cluster 24 P* KULIK Algorithm and tool for active dialogue

Cluster 25 P* MIGUNOVA ea. Human factors and programming

Cluster 26 P* MEL'NICHUK ea. Ecological education

Fig. 3. The cluster tree for EWHCI'92 reports (continued).

4 Conclusions

1. In general, the cluster tree demonstrates a high level of interpretability. Most top level clusters may be given the same names as conference sessions. For example, Cluster 1 in Figure 3 can be interpreted as "Activity Theory Approach to HCI," Clusters 2 and 6 as "General Principles, Design Methodologies and HCI Models," Cluster 3 as "CSCW," Cluster 5 as "Graphical Interfaces," Clusters 6 and 13 as "Hypertext and Hypermedia," Clusters 7 and 14 as "Psychological Aspects," Clusters 8 and 9 as "Knowledge and Data Based Systems," Cluster 10 as "Computer Assisted Learning and Education," Clusters 11 and 12 as "User Interface Design." At the same time, although the overall structure of the cluster tree reproduces the conference sessions, the placement of particular papers into conference sessions often differs from their placement within the cluster tree. In our opinion, in many cases the cluster tree represents better classification of papers than that provided by conference programme. (A good example of such cluster is Cluster 12 that join up papers on object-oriented interface design presented at three quite different sessions.)

2. The poster presentations, which were not structured according the conference sessions, were successfully classified and included into appropriate classes (see, for example, Clusters 4, 9, 10, 12 and 13). This means that our experts had really used their "cognitive maps" for interpretation of items they sometimes were not familiar with.

3. There is general agreement between the representational structure revealed in our study and the actual conference programme. However, the experts had not simply accepted the existing classification of papers. First, most top level clusters are decomposed into smaller ones, i. e. in contrast to the conference programme sessions they have internal structure as well. Second, a number of clusters were composed of papers presented at different conference sessions (see Clusters 2, 6, 10 and 12).

4. It can be hypothesized that the top level clusters reflect the different representational status of different HCI topics. Items related to educational aspects are represented by one cluster (see Cluster 10). At the same time, there are several clusters somewhat related to visualization (Clusters 5, 15, 19 and 20). This probably means that "Visualization in HCI" has a higher representational status as compared to educational aspects, since the latter is represented at the same level as particular subdomains of the former.

5. The Activity Theory approach to the HCI, based on ideas of the Moscow psychological school, remains rather unusual and not quite comprehensible to the Western experts participating in the study. The cluster of Activity Theory related papers (Cluster 1) has no internal structure, in contrast to most other top-level clusters. It might be supposed that experts operated on a "word label" level, simply attributing all Activity Theory related papers to the same class without expressing finer shades of distinction.

6. The analysis of "residua," that is the papers which do not belong to any group and compose one-item isolated clusters (Clusters 16-26), reveals that there are several types of papers which do not fit into the general scheme. These are: (a)papers introducing new approaches (e.g., "fractal approach" or "parametric synthesis"), (b)very specific papers (e.g., "Human Factors in ELOIS System"), and (c)very general ones (e.g., a paper on "human factors, dialogue problems, and programming effect").

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Coupling Interaction Specification with Functionality Description

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Abstract

In this paper, the solution used in the context of SEPDS (a Software Development Environment) to the problem of combining interactive behavior specification with functionality description of a distributed interactive application is presented. This solution consists of combining two specification models: IDFG to describe the interactive aspects of applications developed with the system and EDFG to describe their functionality. Both these models are data flow graph based and can be classified as process models. They use "actors" to represent performers of processes and "links" to represent data buffering and exchange, as well as roles and different perspectives. Although the two models have many semantical differences, they also have many common properties, that is why they can be straightforwardly combined in a process that enables designers think in users terms. To this end, action actors are used to represent the functions supported by the application, and context actors to represent the application user interface functions. In addition, links are used to represent the events that take place in the system (these may be user or system actions), the effects that these have on the screen, the context into which these take place and the goals that may be achieved using the application. Furthermore, the reusability and prototyping tools of SEPDS can be used to construct and test the application design.

1 Introduction

The need to build increasingly complex software systems has led in the development of SDEs (Software Development Environments) [6, 9], which not only provide assistance in software development, but also guarantee a standard level of quality, as they progressively integrate tools that support more phases of the software development process. With the evolution of technology, the need to build highly interactive applications that address non–computer expert users has recently come up. Despite the attempts, however, there still exists a gap between the designers' and users' model of an interactive application, due mainly to the unsuitability of the traditional application development techniques for the specification of interaction and the construction of user interfaces [11], and to the difficulty of combining an interaction model with an application data model [1].