Modality Theory and Information Mapping

Overview and Summary of the Deliverable

1. Introduction

Research Package 5 is directed at the integrated development of modality theory, i.e. a systematic framework which includes (a) exhaustive taxonomies of input and output modalities of information representation at the human-computer interface, (b) systematic analyses of the modalities in the taxonomy, (c) a methodology for applying the theory in practical interface design, called the information mapping methodology or IMAP, and (d) explorations of how to transfer, through automation or otherwise, the methodology as a design support tool. Modality theory, including the hypertext/hypermedia taxonomy workbench and theory demonstrator, is primarily being developed at CCS. CCS and ESADG have been jointly engaged in interface design case studies in order to explore the requirements to be satisfied by an information mapping methodology which could be applied in practical design. ESADG has done a study of the state-of-the-art in the domain of input modalities.

Modality theory explores input and output modalities as vehicles for the representation and exchange of information at the human-computer interface. Modality theory may be seen as belonging to a new generation of science-based theories in human-computer interaction (HCI) research, in the following sense. For 5 years or so, the importance of addressing the problems involved in bridging between basic theory and design practice has been high on the agenda of research in HCI. These problems are now seen as being both non-trivial and complex in their own right, and the need for 'bridging' representations between basic science and design practice is widely recognised. The information mapping methodology is an integral part of modality theory and is being designed to serve as such a 'bridging' representation. Moreover, the basic concepts and the entire conceptual structure of the theory itself has been conceived with design support in mind. The aim has been to let theory development be driven by practical (interface design) needs to the extent possible without sacrificing theoretical soundness and robustness.

Despite a slow start because of change in personnel (Michael May having been replaced by Flemming Jensager with four months delay), year 3 of AMODEUS-2 has seen substantial consolidation of modality theory. Part of these results are presented in the present Deliverable D15. Further consolidation will take place between now and the formal end of the project in October 1995, by which time we will have recovered from the delay just described. These are reviewed below in terms of theory consolidation (Section 2), methodology consolidation (Section 3), and workbench consolidation (Section 4). Section 5 describes other beyond-working-paper level publications during year 3 of AMODEUS-2. Attached to the list of references is a list of all RP5 publications since RP5 was included in AMODEUS-2 one year and eight months ago in November 1993. Papers and publications produced after M2 have been marked.

2. Theory Consolidation

At M2, we presented a generation of the taxonomy of unimodal output modalities at the generic level of abstraction. The generation was published in *Interacting with Computers* in December of 1994. Meanwhile, a number of difficulties with the generation had been identified. These problems have been addressed and solved in the first paper in this deliverable (Bernsen 1994, see Part B below). This paper presents a transparent version of the generation of the taxonomy of unimodal output modalities. The paper will be submitted for journal publication. In the second paper, the generation of unimodal output modalities has been extended one level down in the abstraction hierarchy, to what we term the 'atomic' level and, in two cases, further downwards to the 'sub-atomic' level (Bernsen 1995a, see Part C below). The result is a version of the taxonomy which

provides a 'designer's toolbox' of output modalities. The paper will be submitted for journal publication. All modalities in the taxonomy have been analysed in a common format and results represented and illustrated in the taxonomy theory demonstrator (Section 4 below).

With respect to input modalities, we announced at M2 that a taxonomy of input modalities would be built around the concept of an interactor. However, further work has shown that generation of a taxonomy of unimodal input modalities at the generic level of abstraction should be done according to principles more similar to those applied in the generation of the output modality taxonomy. The reasons why input modality generation was found to be a rather hard problem, were that we first had to dissociate input modalities from all issues of human-computer *interaction* proper. Secondly, input modalities had to be completely dissociated from input *devices* with which they are commonly confused. And, thirdly, the haptic medium of expression had to be removed from input modality analysis and replaced by the *kinaesthetic* medium of expression. Once these steps had been taken, the generic level generation of a taxonomy of input modalities proved rather straightforward. First results are presented in the third paper in this deliverable (Bernsen 1995b, see Part D below). The paper includes a description of the next steps in the generation process. We will try to get as far as possible along these lines during the coming months. Part E below (Verjans 1995) presents a study of the state-of-the-art of input modalities, which will be important to our work on input modalities towards the end of AMODEUS-2.

3. Methodology Consolidation

IMAP consolidation is done largely through design case studies. At M2, we had just completed the PaTerm case study which demonstrated that IMAP was incapable of handling low-level interface design details. It therefore became important to investigate the exact scope of the methodology. This was done in the CERD case study, CERD being a shared design exemplar of AMODEUS-2. The fifth paper in this deliverable presents the CERD case study (Bernsen and Verjans 1995a, see Part F below). In this paper, the scope of IMAP is defined and related to the novel concept of an *abstract interface sketch* and a description of abstract interface objects. IMAP produces an abstract interface sketch which can be used for first analyses of human-computer interaction with the artefact being designed. A journal paper has been submitted which describes the consolidated version of IMAP that resulted from the series of three different case studies done in AMODEUS-2 (Bernsen and Verjans 1995b).

During the first quarter of 1995, the consolidated version of IMAP that resulted from the CERD case study has been applied in real-time to a Danish industrial interface design project. We call this case study the PCI (plant-computer interaction) case. The industrial design problem was the re-design of a commercial table-based greenhouse climate control system. In the new design, tables would be replaced by a series of analogue, and partly animated, graphics interface presentations. The application has four main screen templates and many hundreds of individual monitoring and control screens. Three papers have resulted from this case study, one of which can be found in the RP3 deliverable (Ramsay 1995). This paper is on the use of DSD as a support of IMAP in the design process. The two other papers are being completed at the time of writing. One is about the actual process of applying IMAP in industry (Jensager and Bernsen 1995), the other is about the IMAP reasoning process itself and the abstract interface sketches it produced (Bernsen, Jensager and Lu 1995). As regards their contents, the two first-mentioned papers actually belong to RP4, "Transfer and Assay", as they represent work at the destination of the AMODEUS-2 project, i.e. the testing of approaches in real design environments. One result of the PCI case study worth mentioning here is that IMAP has been further consolidated through the development of a stepwise procedure to be followed in applying the methodology during interface design.

4. Workbench Consolidation

The final paper in the present deliverable was presented at Eurographics in Toulouse and will be published by Springer Verlag. It provides a consolidated presentation of the hypertext/hypermedia

modality theory demonstrator (Bernsen and Lu 1995, see Part G below). The theory demonstrator contains a complete presentation of the modalities that were generated for the taxonomy of unimodal output modalities. Since M2, a considerable amount of work has gone into the selection of hundreds of appropriate illustrations of the modalities represented in the theory demonstrator. Now that the 'toolbox' of output modalities is complete and in the process of publication, we will seek ways of publishing the full output taxonomy including the modality analyses, be it in book form or on a CD-ROM.

5. Other Publications in Year 3

Bernsen and Verjans (1995c) has been published in *Proceedings of the CHI '95 Workshop on Knowledge-Based Support for the User Interface Design Process,* Denver, Colorado May 1995.

Lu and Bernsen (1995) has been published in *Proceedings of the 4th International Conference on Interface to Real and Virtual Worlds,* Montpellier, 27-29 June 1995.

Bernsen (1995c) is being published by Springer Verlag.

Bernsen (1995d) is being published in *Proceedings of the First International Workshop on Intelligence and Multimodality in Multimedia Interfaces: Research and Applications,* Edinburgh, July 1995.

Verjans (1994) is Steven Verjans' Masters Thesis. Steven now holds two Masters degrees.

References

Bernsen, N.O. (1994) A revised generation of the taxonomy of output modalities. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP11. Journal submission.

Bernsen, N. O (1995a) A toolbox of output modalities. Representing output information in multimodal interfaces. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP21. Journal submission.

Bernsen, N. O. (1995b): A taxonomy of input modalities. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP22.

Bernsen, N.O. (1995c) Why are analogue graphics and natural language both needed in HCI? To be published in the *Focus on Computer Graphics* Series by Springer Verlag. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP3 and RP5-TM-BC15.

Bernsen, N.O. (1995d) Information mapping in practice. Rule-based multimodal interface design. To appear in *Proceedings of the First International Workshop on Intelligence and Multimodality in Multimedia Interfaces: Research and Applications,* Edinburgh, July 1995. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP16 and RP5-TM-CP91.

Bernsen, N.O., Jensager, F., Lu, S. (1995) Designing interfaces by information mapping. An industrial case study. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP18.

Bernsen, N.O. and Lu, S. (1995) A software demonstrator of modality theory. In Bastide, R. and Palanque, P. (Eds.): *Proceedings of DSV-IS'95: 2nd Eurographics Workshop on Design, Specification and Verification of Interactive Systems,* Toulouse 7-9 June 1995 *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP15 and RP5-TM-CP87.

Bernsen, N.O. and Verjans, S. (1995a) Designing interfaces by information mapping. A case study of the CERD design. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP13.

Bernsen, N.O. and Verjans, S. (1995b) From task domain to human-computer interface. An information mapping methodology. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP17. Journal submission.

Bernsen, N.O. and Verjans, S. (1995c) Information mapping. Knowledge-based support for user interface design. In *Proceedings of the CHI '95 Workshop on Knowledge-Based Support for the User Interface Design Process,* Denver, Colorado May 1995. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP14 and RP5-TM-CP82.

Jensager, F. and Bernsen, N.O. (1995): Monitoring and control interface design through information mapping. *Esprit Basic Research project AMODEUS-2 Working Paper* RP5-TM-WP19. (Forthcoming).

Lu, S. and Bernsen, N.O. (1995) The taxonomy workbench. A multimedia database system for analysing representational modalities. In *Proceedings of the 4th International Conference on Interface to Real and Virtual Worlds,* Montpellier, 27-29 June 1995. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP12 and RP5-TM-CP86.

Ramsay, J. (1995) Promoting plant-computer interaction. Developing a design space for greenhouse monitoring and control. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP4-TA-WP44.

Verjans, S. (1994) Computer semiotics as a basis for integrating different views in human-computer interaction. *Esprit Basic Research project AMODEUS-2 Working Paper* RP5-TM-WP10, 1994.

Verjans, S. (1995) State-of-the-art for input modalities. *Esprit Basic Research Project AMODEUS-2 Working Paper* RP5-TM-WP20.