MODALITY THEORY

Activities and Results in AMODEUS-2

Work on modality theory development was added to AMODEUS-2 in November of 1993. The work on modality theory carried out at CCS and ESADG during the past 20 months of AMODEUS-2 relates to the following TA objectives.

General Aim (A) *To establish a set of related frameworks for expressing different aspects of the design of user-system interaction.* The proposed work on modality theory will provide a framework for expressing the representational aspects of interface design.

General Aim (B) *To extend the scope of basic modelling techniques to provide analytic leverage on the problems of user-system interaction with sophisticated interactive technologies.* The information mapping methodology of modality theory will be extended to address the potentially complex representational issues involved in the design of multi-modal multi-media (M4) systems.

General Aim (C) *To assess how mediating expressions, modelling techniques and the substantive principles they convey may successfully be transferred to and used by the design community.* We will work towards the goal of assessing the usability of information-mapping techniques in interface design.

In addition, the work has added one specific objective to the eight specific objectives on the AMODEUS-2 research agenda:

Specific Objective (9) *The development of modality theory, i.e. a systematic framework for the analysis of input/output modalities of information representation and a methodology for applying the theory in practical interface design.*

The work performed has pursued the following objectives::

1. To establish a taxonomy of the unimodal modalities which go into the creation of multimodal output representations of information for human-computer interaction (HCI). When coupled with concepts appropriate to modality analysis, this should enable the establishment of sound foundations for describing and analysing any particular type of unimodal or multimodal output representation relevant to HCI;
2. to establish a corresponding taxonomy and related analyses of the unimodal input modalities which go into the creation of multimodal input representations for HCI. This should enable the establishment of sound foundations for describing and analysing any particular type of unimodal or multimodal input representation relevant to HCI;
3. to establish a "grammar" for how to legitimately combine different unimodal output modalities, different unimodal input modalities, and different input and output modalities for the usable representation of information at the human-computer interface;
4. to develop a methodology for applying the results of the steps above to the analysis of the problems of information mapping between work/task domains and human-computer interfaces in information systems design;
5. to use results in building, possibly automated, practical interface design support tools.

These objectives form the research agenda of modality theory which addresses the following, general information mapping problem: *Given any particular set of information which needs to be exchanged between user and system during task performance in context, identify the input/output modalities which constitute an optimal solution to the representation and exchange of that information* (Bernsen 1995a, cf. Bernsen 1993).

The CCS/ESADG AMODEUS-2 RP5 activities will be described below following the research agenda of modality theory.

Objective 1 on the research agenda of modality theory has been achieved. A consolidated theory of output modalities is now in place (Bernsen 1994a, 1994b, 1994c, 1994d, 1995a, 1995c, May 1994, cf. also Verjans 1994).

Objective 2 on the research agenda has been achieved to the extent that a taxonomy of input modalities has been developed at the so-called "generic" level of abstraction (Bernsen 1995b). It follows from the principles used in the generation, that about two thirds of the "atomic" level taxonomy have been achieved as well. This is because these parts of the input taxonomy will be identical to the output taxonomy presented in Bernsen (1995a). What remains to be done is to develop the atomic-level input taxonomy to cover kinaesthetic input modalities. The plan is to complete this work before the formal end of the AMODEUS-2 project. A state-of-the-art paper on input modalities will be very helpful to this end (Verjans 1995). What remains to be done on Objective 2 of modality theory is very important and unfortunately cannot be done within the time limits of AMODEUS-2. This is to develop a full modality analysis of input modalities corresponding to the one which has been developed for output modalities. Funding for this work will be sought elsewhere.

Objective 3 on the research agenda presupposes consolidated results on Objectives 1 and 2. Funding for this work will be sought elsewhere.

Objective 4 on the research agenda has been achieved based on a series of interface design case studies (Verjans and Bernsen 1994, Bertels 1994, Bernsen and Verjans 1995a). A consolidated methodology for information mapping is now in place (Bernsen and Verjans 1995b, Bernsen and Verjans 1995c). In addition, a first assay and transfer test has been made of the methodology. The methodology was applied to a Danish industrial interface design project in which the CCS modality theory group acted as consultants. Two papers describing the case are currently being completed (Bernsen, Jensager and Lu 1995, Jensager and Bernsen 1995). A paper describing the role of DSD in the process has been completed (Ramsay 1995).

Objective 5 on the research agenda of modality theory aims at "complete transfer", that is, at making the results of basic science, such as modality theory, independent of those who created them. The aim thus is to package these results in a way which makes them usable by practical designers independently of the presence of consultants with extensive knowledge of the science base. Towards this aim, two versions of a hypertext/hypermedia modality workbench and theory demonstrator have been developed (Bernsen, Lu and May 1994, Bernsen and Lu 1995, Lu and Bernsen 1995). The problem of creating a rule-based design support tool from the workbench is discussed in Bernsen (1995d). After AMODEUS-2, funding will be sought for preparing a book and a CD-ROM version of input/output modality theory, for turning the information mapping methodology into a transferable walkthrough method, and for specialising the approach to areas such as the design of multimedia applications.

REFERENCES

Bernsen, N.O. (1993): A research agenda for modality theory. In Cox, R., Petre, M., Brna, P. and Lee, J. (Eds.): *Proceedings of the Workshop on Graphical Representations, Reasoning and Communication.* World Conference on Artificial Intelligence in Education, Edinburgh, August 43-46.

Bernsen, N.O. (1994a): Foundations of multimodal representation. A taxonomy of representational modalities. *Interacting with Computers* Vol. 6 No. 4, 347-71.

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

Bernsen, N.O. (1994c): Modality theory: Supporting multimodal interface design. In *Proceedings from the ERCIM Workshop on Multimodal Human-Computer Interaction,* Nancy, November 1993. ERCIM Workshop Reports 94-W003 1994, 13-23.

Bernsen, N.O. (1994d): Modality Theory in support of multimodal interface design. In *Proceedings of the AAAI Spring Symposium on Intelligent Multi-Media Multi-Modal Systems,* Stanford, March, 37-44.

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 (submitted).

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.

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.

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 (forthcoming).

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: Second Eurographics Workshop on Design, Specification and Verification of Interactive Systems,* Toulouse, June. Springer-Verlag 1995.

Bernsen, N.O., Lu, S. and May, M. (1994): Towards a design support tool for multimodal interface design. The taxonomy workbench and theory demonstrator. *Esprit Basic Research project AMODEUS-2 Working Paper* RP5-TM-WP5, 1994.

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 (submitted).

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.

Bertels, A. (1994): Eliciting Designer Knowledge: A Study of the Interface Design Activity. *Esprit Basic Research project AMODEUS-2 Working Paper* RP5-TM-WP8.

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, June (forthcoming).

May, M. (1994): Analogue atomic modalities. *Esprit Basic Research project AMODEUS-2 Working Paper* RP5-TM-WP7, 1994.

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. Master's thesis. *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.

Verjans, S. and Bernsen, N.O. (1994): PaTerm: A case study in information mapping. *Esprit Basic Research project AMODEUS-2 Working Paper* RP5-TM-WP6.