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Project name: MagiCster (Embodied Believable Agents)

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1. Summary

This final progress report describes the last stages of the project, including a three- month extension, and hence covers a total of nine months from June 2003 to February 2004. The most intense area of activity concerned the design and implementation of the final demonstrator, prototype 3, although research in all the contributing areas continued, as described below. Communication and collaboration between the partners was significant, as throughout the project,

and the final demonstrator has benefited greatly from input from all the contributing sites.

2. Status

2.1 Resources

Effort in the last semester, plus extension (person- months):

WP	1	2	3	4	5	Total M31-39
EDIN	3.30	9.70	5.40	5.90	9.30	33.60
BARI	2.30	2.60	3.30	5.00	0.30	13.50
DFKI	0.50	0.00	0.50	0.00	0.30	1.30
SICS	1.10	1.20	3.20	1.70	0.50	7.70
ROMA	4.20	1.40	1.68	1.20	0.70	9.18
AME	1.80	0.70	0.71	3.30	0.00	6.51
Total	13.20	15.60	14.79	17.10	11.10	71.79

2.2 Cumulative

Status of deliverables:

Deliv.	Current status	On schedule	Original date	Actual/planned date
D1.1	completed	yes	M06 = May 2001	M06 = May 2001
D1.2	completed	no	M12 = Nov 2001	M13 = Dec 2001
D1.3	completed	yes	M21 = Aug 2002	M21 = Aug 2002
D1.4	completed	no	M28 = Mar 2003	M30 = May 2003
D1.5	completed	yes	M33 = Aug 2003	M37= Dec 2003
D2.1	completed	yes	M06 = May 2000	M06 = May 2000
D2.2	completed	no	M12 = Nov 2001	M13 = Dec 2001
D2.3	completed	yes	M21 = Aug 2002	M21 = Aug 2002
D2.4	completed	yes	M28 = Mar 2003	M30 = May 2003
D2.5	completed	yes	M33 = Aug 2003	M37= Dec 2003
D3.1	completed	yes	M10 = Oct 2001	M10 = Oct 2001
D3.2	completed	yes	M21 = Aug 2002	M21 = Aug 2002
D3.3	completed	no	M28 = Mar 2003	M30 = May 2003
D3.4	completed	yes	M33 = Aug 2003	M37= Dec 2003
D4.1	completed	no	M12 = Nov 2001	M13 = Dec 2001
D4.2	completed	no	M12 = Nov 2001	M13 = Dec 2001
D4.3	completed	yes	M21 = Aug 2002	M21 = Aug 2002
D4.4	completed	no	M28 = Mar 2003	M30 = May 2003
D4.5	completed	yes	M33 = Aug 2003	M37= Dec 2003
D4.6	completed	yes	M36 = Nov 2003	M39 = Feb 2004
D4.7	completed	yes	M36 = Nov 2003	M39 = Feb 2004
D5.1	completed	yes	M06 = May 2001	M06 = May 2001
D5.4	completed	yes	M36 = Nov 2003	M39 = Feb 2004

Cumulative effort since project start (person- months):

	Brought forward	This semester	Total
EDIN	52.60	33.60	86.20
UPENN	5.90	0.00	5.90
BARI	47.89	13.50	61.39
DFKI	55.05	1.30	56.35
SICS	37.86	7.70	45.56
ROMA	62.98	9.18	72.16
AME	40.69	6.51	47.20
Total	302.97	71.79	374.76

The figures below relate final effort to the total estimates in the TA:

	Allocation	Declared	
EDIN	42.00	86.2	205.24%
UPENN	36.00	5.9	16.39%
BARI	32.00	61.39	191.84%
DFKI	32.00	56.35	176.09%
SICS	31.60	45.56	144.18%
ROMA	36.00	72.16	200.44%
AME	41.00	47.2	115.12%
Total	250.60	368.86	147.19%

3. Achievement

3.1 General

Prototype 3 was the main focus of attention throughout the reporting period, with effort concentrating on the practical and theoretical issues involved in integrating all the contributing research areas. D3.4 contains a detailed account of how we approached and, where possible, resolved these issues.

Note that in accordance with the project workplan and budget, DFKI only had resources for months 1-29. The remaining resources were used to package the cc-Net module in a way that allows its deployment in Prototype 3 and other applications with animated characters. In addition, technical support, dissemination activities, and communication with other partners have continued without interruption and will be continued even beyond the official project end.

3.2 Workpackage 1

There is an extensive report on the final animation effort on prototype 3 in D1.5, focusing on AME's research on animation. In addition to this, the final MagiCster work on Greta proceeded in 2 directions, concentrating both on improving the lip model and on updating and extending APML.

Lip Model

We extended the lip model to consider emotion, based on data received from the CNR of Padova. The data corresponds to:

- 'aba
- 'ava
- m'amma

Both triphones and the word had been recorded for 7 emotions: neutral, anger, disgust, happiness, fear, sadness and surprise. The CNR of Padova uses the Elite system, as described in the Deliverable 1.3, for the recording. The data provide the temporal course of 7 labial parameters: upper lip height (ULH), lower lip height (LLH), lip width (LW), upper lip protrusion (UP), lower lip protrusion (LP), aw (AW) and lip corners (LC). From the data, we have extracted the maximum or the minimum (target point) to characterize each viseme (see Deliverable 1.3 for further information). Vocalic and consonantal data were stored in a database. Besides targets value, other information, such as the vowel or the consonant that defines the context, the duration of the phoneme and the time of the targets in this interval, were collected.

Given this data, we developed an algorithm to allow for the computation of affective lip movement. Each emotion is described using a 7x7 matrix. The rows are the seven recorded emotions, whereas the columns are the lip parameters. A value in the matrix represents the percentage of dependence that the corresponding lip parameter has on the corresponding fundamental emotion. Therefore, the value of the targets for each labial parameter will be an interpolation among the targets in the fundamental emotions that have a value on the column different from zero. Obviously the fundamental emotions all have the value 1 in the row corresponding to the emotion itself.

To further reinforce the expressiveness of the lip movement during emotional speech, we have defined two qualifiers. These qualifiers modulate the expressiveness of a movement. The first, *Tension Degree*, can have the following values: Strong, Normal and Light. It simulates different intensities of muscular strain. For example, the emotions 'anger' and 'fear' are characterized by a Strong Tension Degree. The second qualifier, *Articulation Degree*, can take the values Hyper, Medium and Hypo. It defines how Greta articulates words. For Hyper Articulation the lip movement amplitude of the 3D agent will be wider than normal.

Communication of the Emotions: Update of APML

We realized some modifications to the APML language in order to allow the Greta

agent to communicate a wider variety of facial expressions of emotion as well as to allow for a more flexible definition of facial expressions and their corresponding parameters. These modifications refer mainly to the timing of facial expressions as well as to their intensity; intensity corresponds to the amplitude of facial muscle movements. An APML tag defines the meaning of a given communicative act (see progress report 1, M01-M06); The Greta engine looks up a library of expressions to instantiate this meaning with the corresponding facial expression. A facial expression has 3 temporal parameters: onset, offset and apex. In the previous version of the Greta engine, the value of the onset and of the offset were set as constants. An expression was set to start at the beginning of the tag and to finish at its end. That is the apex of an expression was set to be the total time length of a tag (computed as the duration of the speech embedded in the tag; this duration being provided by the speech synthesizer) minus the onset and offset time. The previous version of APML did not allow the modification of any of these parameters. We therefore extended APML to provide a mechanism for directly altering the temporal parameters of an expression.

For each AMPL tag we have introduced 5 new attributes:

- DELAY: specifies the percentage of delay before an expression arises; it forces the Greta engine to delay the start of an expression for a certain time. This time is specified by a percentage of the total default animation time (that is the time of the speech embedded in the XML tag). The default value is 0 (that is there is ``no delay"); this corresponds to the previous version of APML.
- DURATION: specifies the total duration of an expression, as a percentage of the default expression duration. The Greta engine will set the duration of an expression (the apex of an expression) to last for this new value. The default value is 100% (that is ``normal duration"); this corresponds to the previous version of APML.
- ONSET: specifies a value for the onset. This value is given as a number of animation frames that the engine must use to render the ``onset" phase of an expression. The default value is 0 (that is the onset is set to a constant value as defined in the previous version of APML).
- OFFSET: specifies a value for the offset. This value is given as a number of animation frames that the engine must use to render the ``offset" phase of an expression. The default value is 0 (that is the offset is set to a constant value as defined in the previous version of APML).
- INTENSITY: corresponds to a factor that multiplies the quantity of movement of each FAP involved in the facial expression. Until now the facial expression corresponding to a meaning for a given communicative act was explicitly defined and it was not possible to modify such values on the fly. In order to have a facial expression with lower or greater intensity, one had to create a new entry in the library of expressions. This was quite cumbersome. We remedied this lack of flexibility by introducing an intensity factor that can automatically modify any defined expression. As an expression corresponds to a set of FAPs, the change of intensity corresponds to a modification of the

value of each FAP. The default value is 1, meaning that values of the FAPs defining an expression in the library of expressions are not changed.

Let us consider the following example:

```
<theme belief-relation="gen-spec" affect="sorry-for"> ...
some text...
</theme>
```

The timings of the expression as evaluated in the tag are given in the Figure 1.

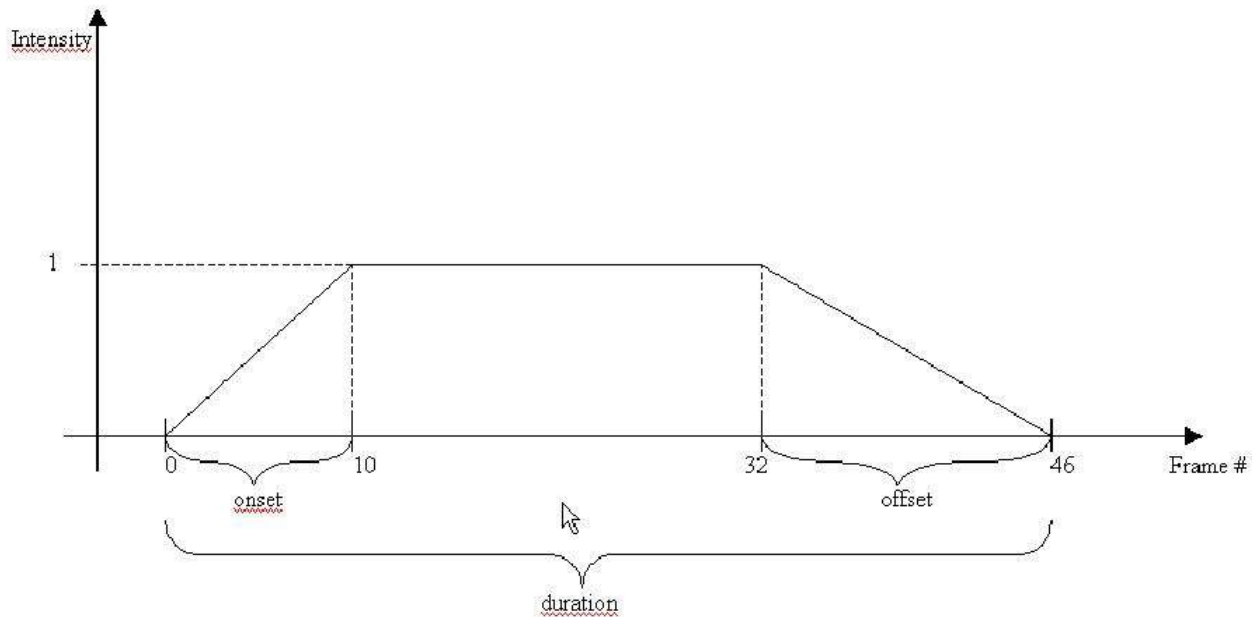


Figure 1: Temporal course of a facial expression

Let us consider now the same example with the introduction of the new tags. For example we may have:

```
<theme belief-relation="gen-spec" affect="sorry-for" delay="40%"
duration="40%" onset="4" offset="4" intensity="1.5">
some text
</theme>
```

The type of expression evaluated in the tag remains unchanged; what change are the temporal and intensity parameters of the expression. Figure 2 illustrates these changes.

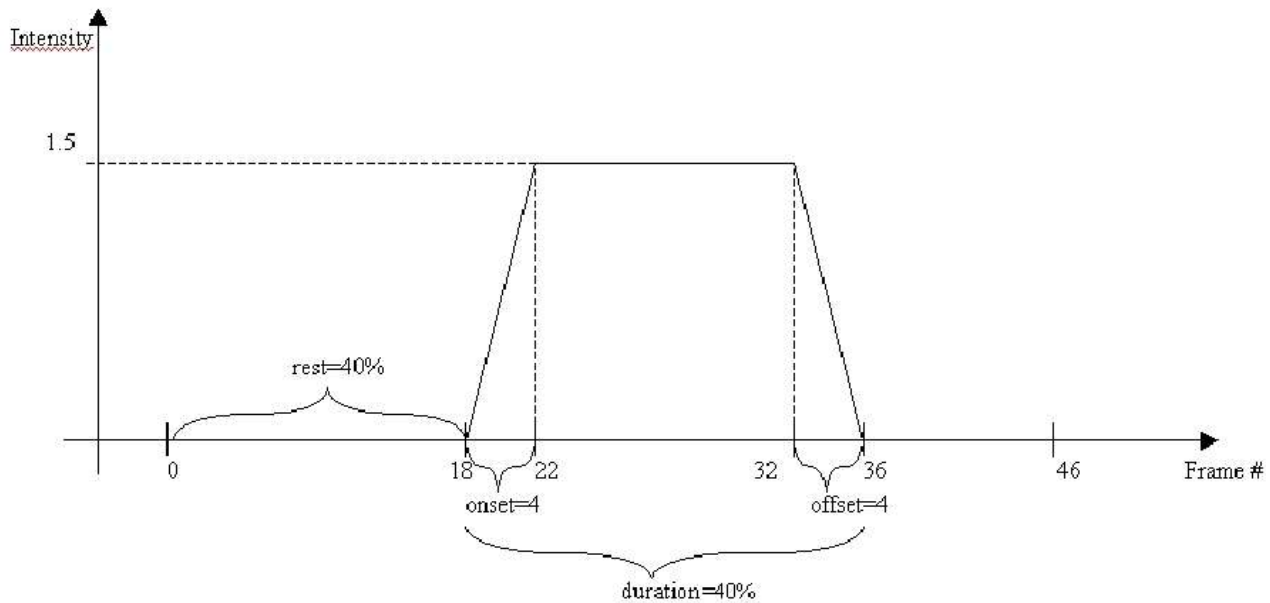


Figure 2: Temporal course of a facial expression when taking into account the new APML modifiers.

3.3 Workpackage 2

The language and speech effort focussed mainly on Dipper in the final stages of the project, and full documentaion of the capabilities of the system are contained in D2.5 and D4.7; as detailed there, the range of agents available in Dipper has been refined and extended. In addition, we have continued to work on Festival and an APML, which of course functions as the communication language.

As noted in the previous progress report, support for APML was included in version 1.4.3 of Festival, and this software is available for download from the MagiCster web pages:

<http://www.ltg.ed.ac.uk/MagiCster/deliverables/>

Research on speech synthesis has focussed on ways to make use of the rich intonational mark-up supplied by APML. This involved the implementation of new modules for Festival in order to map the information contained within the APML structure onto the structures that Festival uses. Phrasing is assigned using a combination of punctuation and boundary elements, and accents are assigned using the emphasis elements.

The main recent development is a new model to create pitch contours which can generate a full complement of accents and boundaries that can be specified by the APML mark-up, as Festival's default models only generate a small subset of these in a meaningful way. This involved the inclusion of prosodic structure and the isolation of parameters representing particular accent shapes.

All of the modules are designed to be flexible enough to adapt to the specific needs of the project as those needs change. The way in which any part of the intonation is generated can easily be modified if necessary. In addition to APML support, recent improvements include:

- *Pauses*; the need for more flexibility in the length of pauses between and within utterances has been addressed by incorporating a way to specify pause length directly in the APML markup. A pause element with an attribute specifying the length of pause required was added to the APML specification. Thus, for example, `<pause sec="2.0">` specifies a two-second pause.
- *Voice initialisation*; the need to initialise voices in different languages in different ways when using APML was also addressed by generalising the APML initialisation procedure. This now works for both English and Italian, and the call to the `apml_initialise` function automatically determines what action is appropriate for the current voice.

Work on APML continues, and will continue after the end of MagiCster as a number of other research projects are now using it. The project's adoption and development of APML has therefore contributed significantly to the establishment of standards in the areas of the turn-taking, performative, affective, and intonational aspects of text for speech synthesis and facial animation (see de Carolis et al. 2004).

3.4 Workpackage 3

To recap briefly, our work on emotion modelling has centred on three prototype systems:

1. a testbed for simulating activation of mixed emotions with dynamic belief networks (*Mind- Testbed*)
2. an executable version of the tool (*Executable- Mind*) which could be integrated with the dialogue simulator and with any other external device;
3. a domain- independent *dialogue- Testbed* for building, testing and revising models of affective dialogues and for checking how the dialogue is influenced by the agent's 'personality' and by the social context in which the dialogue occurs.

In the final phase of the Project, we worked in two directions.

- On the one hand, we refined the dialogue simulation to adapt advice-giving to the affective state of the user: we introduced a user modeling component and revised knowledge representation in the TrindiKit to enable a more flexible and dynamic activation of the agent's goals and plans during the dialogue.
- On the other hand, we developed an *executable version of the Affective dialogue Simulator* which was designed to enable interactions with the Conversational Agent in a *Smart Environment*.

The executable version of the Affective dialogue simulator may be activated in *server* or in *local* mode. The server mode enables a remote user to interact with the Conversational Agent through a socket communication and with an handheld computer. The local mode enables users to interact with the system through a touch screen. In both cases, an initial setting phases enables the system administrator to settle the dialogue conditions: application domain an agent's *appearance and personality*. The Conversational agent may take, in Prototype 2, three 'bodies': Greta, Ozzar (one of MS-Agents characters) and Flora (an Haptel agent). In all cases, the input move is passed to the agent in the form of an AXML file: the specific body to employ is selected so as to tailor it to the application domain (Flora for the travel agency, Greta for advice to adults about eating disorders and Ozzar for advice to teenagers in the same domain).

This work is described extensively in Deliverable 4.7

3.5 Workpackage 4

During the last period of the project we worked extensively on completing the player object based on AME rendering technology and the Greta server for prototype 3. This work resulted in a player object integrating the Greta server for generation of FAP/WAV files and the AME rendering engine for playing the generated files. We have also worked on a language understanding module for the final prototype. The module uses regular expressions to match sentences directly with dialogue moves. Hence the power of the module is dependent on the number and quality of the expressions. An account of the language capabilities is included in D2.5, and D3.4 contains a full description of the prototype.

We experienced some delays in the prototype 3 research. One reason for this was the need for a rewrite of the cinematography component due to the fact that the undergraduate students working in this area at SICS were unable to deliver in time. The component was however successfully re-implemented, albeit in a somewhat scaled down version. All the features of the initial cinematographer are still present (different shot types, animated shots, borders, and so on) but the structure of the cinematographer is simpler. Instead of consisting of the planned five parts (director, idioms, cutter, producer, projector) doing different tasks such as choosing idioms and arranging a screen layout, there are only three major components; the cinematographer, idioms and shots. While the cinematographer chooses which idiom to use, idioms are responsible for selecting shots, borders and arranging a screen layout. In addition we added scripting support to the cinematographer thereby making it possible to create new idioms and shot types without recompiling the system. One effect of the delay is that the evaluation of prototype 3, which we intended to begin (although not finish) during the project, has been postponed. An evaluation plan for the prototype is included in D4.6.

As mentioned in previous reports, we undertook extensive evaluation studies in cooperation with the University of Reading. These studies were designed to

evaluate Greta empirically in the application domain considered in Prototype 2 and was developed by the University of Reading, in cooperation with the University of Bari and in the scope of a subcontract from this University. Greta's videos were prepared by the University of Roma La Sapienza in cooperation with the University of Edinburgh, according to a study design that was agreed among the participant researchers.

Over the course of six experiments, we tested over 334 participants, in an effort to answer two major questions:

- Firstly, *what are the benefits (and costs) of presenting information via an animated agent compared to other forms of display?*
- Secondly *how important is achieving consistency between verbal and non-verbal behaviours in animated agents?*

To do this, we created a healthy message that was consistent with the application domain of Prototype 2 (see D3.3 and D4.4) and employed various versions of Greta which were available from mid 2002. Across the six experiments, the message was presented variously as a text or by Greta, a human actor or via Greta's voice (no face). We also employed two new versions of Greta, in which she displayed additional facial expressions that were either consistent or inconsistent with the content of the healthy eating message. In contrast to many existing evaluation studies (see e.g., Dehn & van Mulken, 2000), we used a wide range of test measures to assess users' performance following presentation of the message. These included, among other things, *cognitive performance* and *behavioural intention measures* and were designed to ensure that even very subtle effects were detected.

Overall, we found that presenting the healthy eating message via Greta generally led to poorer cognitive performance than any other form of presentation. However, when Greta's behaviour was consistent, this negative effect disappeared. As such, the findings clearly point to the importance of achieving consistency of behaviour in animated agents. We conclude by noting that future advantages to using multimodal agents are likely to appear, as researchers increase factors such as the level of interaction between user and computer.

A detailed description of methods and results of these experiments, with a discussion of findings, is given in the Deliverable 4.6.

3.6 Exploitation

The MagiCster prototypes and the MagiCster additions to the AME player engine / tools have already opened up several exploitation possibilities:

- Avatar Arena (DFKI) (prototype 1) is an entertaining prototype that has already been successfully used in event situations such as the IST Conference. AME and DFKI have made an agreement enabling AME to integrate Avatar Arena with the AME player engine / tools, and AME to supply Avatar Arena to customers with its AME player

engine / tools as a fully credited working example application.

- The Affective Dialogues prototype with Greta (prototype 2) is of very high animation quality and as a result of the MagiCster architecture and the close collaboration between MagiCster partners, AME is in a technical position to integrate it and supply it to customers as an example application.
- The SICS Game (prototype 3) covers many areas and has a focus on cinematography. It is already integrated with AME technology, and AME can supply it to customers as an example application. Furthermore, customers can use it to experiment with cinematographic approaches and build their own scenes using the AME tools.
- DFKI has ported Avatar Arena (prototype 1) onto Charamel; the result could be used by Charamel users.
- Bari has developed a wrapper for Affective Dialogues (prototype 2) for Hapttek; this means that Hapttek users could access this MagiCster prototype.
- The IST NECA project has developed an eShowroom application (<http://www.eshowroom.org>). The AME Engine, developed partly under the MagiCster project, will be linked with the eShowroom application developed in the NECA project by AME as a commercial demonstrator.
- The IST VIP Advisor project, which ends in Feb 2004, has already used some of the AME tools developed in the MagiCster project in its Online Risk Management Advice prototype. This application may also be available to AME to provide to its customers as an example.

Most of the prototypes are to be implemented through the project's industrial partner AME. MagiCster has been particularly valuable for AME, because without example content, even the best player in the world will have very little commercial uptake. MagiCster has made available a range of five good example applications for AME and its customers including AI and graphics teams worldwide. The AME engine also forms a good base for future research projects in which AME is involved.

AME has submitted a world PCT/GB03/0031 patent application 'Avatar User Interface' published as WO 03/08512 A2 to protect its technology including that developed during the MagiCster project. The patent application is very large with 147 pages of text and 60 Figures. No Protection of Knowledge costs are to be claimed on MagiCster by AME. This patent application contains both Exploitation and Dissemination work for MagiCster. Since patent applications are not preceded by papers in public journals, most researchers in the field regularly carry out patent searches of the area as part of their appraisal of the state of the art and the MagiCster work disclosed in the patent application will be disseminated to them.

4. Management

No management problems were encountered, and the project has accomplished its major goals on schedule. In retrospect, the most significant alteration to the original project plan concerned the withdrawal of the University of Pennsylvania as a full partner, as mentioned in the progress report for M07- M12, due to the

failure to find matching funding in the US. The effect of this withdrawal was minimised as a result of the move from the planned use of PARs to APML. APML proved to be an excellent vehicle for communication between the relevant modules and its take-up in other projects suggests that it is becoming a standard.

5. Dissemination and Awareness

Publications:

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E. Bevacqua, M. Maurizio, C. Pelachaud, *Speaking with emotions*, submitted to AISB'04.

M. Bilvi, C. Pelachaud (2003), *Communicative and Statistical Eye Gaze Predictions*, Workshop Embodied Conversational Characters as Individuals, Second International Joint Conference on Autonomous Agents Multi-Agent Systems, Melbourne, Australia, 15th July 2003.

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J. Laaksolahti, N. Bergmark and E. Hedlund (2003) *Enhancing Believability through Affective Cinematography*, in Lecture Notes in Artificial Intelligence, vol 2792, pp. 264- 268, Springer Verlag

C. Matheson, C. Pelachaud, F. De Rosis and T. Rist (2003). *MagiCster: Believable Agents and Dialogue*. Special Issue of Künstliche Intelligenz on Embodied Conversational Agents, 2003.

C. Pelachaud, M. Bilvi (2003). *Modelling Gaze Behavior for Conversational Agents*, IVA'03, 4th International Working Conference on Intelligent Virtual Agents, Germany, September 15- 17, 2003.

I. Poggi, C. Pelachaud, E. Magno Caldognetto (2003). *Gestural Mind Markers in ECAs*, poster at Second International Joint Conference on Autonomous Agents Multi-Agent Systems, Melbourne, Australia, 14- 18 July 2003.

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M. Steedman and J. Baldrige (2004). *Combinatory Categorical Grammar*, in Kirsti Börjars and Bob Borsley, (eds.), *Non- Transformational Theories of Grammar*, Blackwell Oxford, (to appear).

K. Thomas and C. Matheson (2003). *Modelling concession across speakers in task- oriented dialogue*. Proceedings of Diabrück, the seventh workshop on the semantics and pragmatics of dialogue.

Misc:

Newspaper Article in Competence nr 6, August 03, Framtidens datorspel sociala såpor.

Presentations and Workshops:

The Avatar Arena Prototype was demonstrated to a delegation from VW Autostadt GmbH at DFKI in December 2003. Autostadt is VW's future park where leading edge technology is shown to customers. Autostadt is interested in setting up a new installation with animated interactive characters. Technology developed in MagCister may well be deployed in such an installation.

Thomas Rist was co- chair of the international working conference on 'Intelligent Virtual Agents' which was held 15- 17 September 2003 at Kloster Irsee Germany. MagiCster was presented at this conference through talks by Catherine

Pelachaud, Jarmo Laaksolahti, a poster by Markus Schmitt and Thomas Rist, and a demonstration of the Avatar Arena system given by Thomas Rist. For details of IVA 2003 see <http://www.sigmedia.org/iva03/>

On November 20 Thomas Rist gave an invited talk about Animated Conversational Characters at Trinity College in Dublin. The talk included a demonstration of the Avatar Arena Prototype.

Brigitte Krenn from the Project IST-NECA, Nadia Magnenat- Thalmann from the project LIFEPLUS, and Catherine Pelachaud and Thomas RiB. De Carolis, F. de Rosis, V. Carofiglio, C. Pelachaud, I. Poggi, ``Interactive Information Presentation by an Embodied Animated Agent'', International Workshop on Information Presentation and Natural Multimodal Dialogue, Verona, December 2001. st both from the MagiCster project organised a joint working meeting on 'Gesticons for Expressive Embodied Conversational Characters'. The working meeting took place on Dec. 12. 2003 in Vienna. The program and outcome of the meeting are documented here:

<http://www.ai.univie.ac.at/NECA/GesticonsWS/>

Johan Bos, Valeria Carofiglio and Addolorata Cavalluzzi demonstrated the emotional dialogues prototype (prototype 2) with both the TrindiKit and Dipper at Diabrück, the 7th workshop on the semantics and pragmatics of dialogue, in Saarbrücken, Sept 4th- 6th 2003.

Mark Steedman was involved in a number of presentations and invited talks:

- *Combinatory Logic and Natural Grammar*, Invited paper, Workshop on Logic and Computational Linguistics, LICS Ottawa, June 2003
- *Plans, Affordances, and Temporal Semantics*, keynote address to the conference It's about Time, LSA Summer Institute, East Lansing Michigan July 2003.
- *Scope Alternation and the Syntax- Semantics Interface*, keynote address, Colloque de Syntax et Semantique Paris, (CSSP) October 2003.
- *The Grammar of Musical Chord- Sequences*, keynote address to the session on Mathematical Models for Musical Design, Institute for Operations Research and the Management Sciences (INFORMS), Atlanta October 2003

Jarmo Laaksolahti discussed MagiCster in a radio interview on SISU Radio, October 2003, and taught on a PhD course run by SICS at Stockholm University on interactive storytelling (September 2003)

Meetings:

C. Pelachaud and T. Rist met at Intelligent Virtual Agents, on September 15- 17, 2003, and had several technical meetings covering MagiCster research.

Fiorella de Rosis and her group met with the University of Roma, La Sapienza (Catherine Pelachaud and her group) to prepare the videos to be employed in the experiments, and also with the University of Reading (Dianne Berry) to discuss results obtained at every stage of the evaluation study and to design the following experiments. These on-site technical meetings were supported by an extensive exchange of documents and discussion via email, also with other partners.

A full project meeting was held in Paris on October 3rd 2003:

Present:

Thomas Rist, Fiorella de Rosis, Jarmo Laaksolahti, Catherine Pelachaud, Stephen Crampton, Phil Hand, Polina Yordanova, Mark Steedman, Colin Matheson