**R\_és\_u\_m\_é \_**(non confidentiel) du projet en **f\_r\_a\_n\_ça\_i\_s\_ \_**

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**R\_és\_u\_m\_é \_**(non confidentiel) du projet en **a\_n\_g\_l\_a\_i\_s\_ \_**

Creating believable, human-like performances by virtual actors is an important problem in many digital storytelling applications, e.g. creating non-player characters (NPC) for video games, creating expressive avatars in next-generation virtual worlds, populating movies and architectural simulations with background characters and crowds, creating believable virtual tutors and coaches in educational serious games, and creating believable characters for interactive fiction and interactive drama.

A desirable feature for such applications is the ability to create virtual actor performances which are both expressive and controllable. Motion capture actors are expressive, but once recorded, their performances cannot easily be controlled, edited or modified. As a result, game companies ought to get engaged in extensive motion capture sessions of all actions and moods of all characters in every new game they create. On the other end of the spectrum, procedural 3D animation can be controlled in every detail using sophisticated programming techniques, but they fall short of providing the level of expression required for conveying the subtle inflexions of human-like performances.

Character animation has been tackled through various approaches in the past. To name a few, chosen among those that are directly related to DADA, we can cite: embodied conversational agents (ECA); statistical models learned from motion capture examples; physically-based animation; and speech-driven animation. Very few attempts have tried to merge these various approaches into a single model offering on one hand expressive animation and on the other hand high control over the animation.

In order to make progress in the field, we propose to shift the focus from autonomous *characters* to autonomous *actors*. Autonomous *characters* (such as The Sims) make decisions based on AI models of their personality and goals. In contrast, autonomous *actors* follow a precise script, written by the director. Their autonomy is therefore limited to performing a precise sequence of actions as a result of various « cues » written in the script. Creating such performances procedurally using autonomous actors is a valuable goal because it would make it possible for each performance to be unique, which is widely regarded as an important quality to ensure liveliness and immersion, while maintaining a high level of directorial control. Merging both approaches will allow to create autonomous *actors* able to follow a script (specified in high-level command-like language) that give the main directions the actors ought to follow while adapting their behaviors autonomously to the virtual environment they are placed in that includes objects and other actors.

The DADA project will coordinate the work of four leading research teams in computer graphics, embodied conversational agents, statistical machine learning and theatre studies towards the common goal of advancing the state of the art in autonomous digital actors to the point where convincing dramatic performances can be directed and rendered on a laptop computer by theatre directors.

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The goal of the DADA project is to design, implement and evaluate novel interfaces for directing expressive, autonomous virtual actors, borrowing from established theatre practices. We will combine fundamental research in 3D animation, machine learning and intelligent agent programming to leverage motion capture data sets of professional actors into a virtual theatre company of synthetic actors with acting skills, i.e. ability to respond to a director’s instructions and to perform together on a virtual stage. Virtual theatre will be used as a test application for obvious extensions to other digital storytelling applications.

To reach this ambitious goal, DADA will learn parameterized models of actor’s movements and gestures from existing annotated motion capture databases of actor performances; and create intuitive authoring tools for creating a script of actions and cues in a machine-readable format suitable to real-time control of the virtual actors. More precisely, the academic partners of the project will engage fundamental research along two main directions:

1. Animating autonomous actors procedurally. A key idea in DADA is to separate the animation model into a proxemic component regulating how actors interact with each other and the audience, and a kinesic component regulating how actors use their body language to communicate moods and expressions (Tannenbaum 2014). The proxemic component of animation will drive the positions and orientations of actors on the stage as well as their gaze directions. This component will be driven by a model encompassing the social relations between and the emotional attitudes of the autonomous actors. The kinesic component of animation will drive all other degrees of freedom of the virtual actors. This component will be driven by parametric statistical models trained from an existing motion capture data-set. The separation between the two components is expected to yield important benefits in terms of expressivity and composability.
2. Synchronizing virtual actors to a single story-line using a story-driven architecture of actors following a scripted sequence of instructions. In contrast to previous works, which used programming languages, we will investigate multimodal interfaces offering directorial control in a high-level, pseudo-natural language familiar to the director. The language will be compiled internally to a finite-state machine representation controlling the real-time execution of the autonomous actors.

All developments will be validated by experiments with the theatre department of Paris 8, under the supervision of director Georges Gagneré. Starting from a selection of play scripts in various genres and with increasing complexity, theatre experts will use the DADA tools to create virtual theatre performances in the Unity game engine, including stage movements and actions (entering, exiting, sitting down, standing up, taking and putting objects on the stage); body language expression of the personalities, moods and emotions of the characters; and believable gaze, proxemics and action/reaction behaviors between actors.

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Work will be divided into four main work packages: (WP1) animation of isolated actors; (WP2) interaction between actors; (WP3) authoring and real-time control; (WP4) user evaluations. The general scenario for DADA is as follows: Through the authoring tool (WP3), a script is elaborated by a theater director (WP4); virtual actors act out autonomously the commands of the script to position toward each other and in the virtual space (WP2). The behaviors of each actor is computed taking into account their emotional states and social relations (WP1

**WP1. Kinesic component : Procedural animation models for isolated actors.** We will create multi-modal statistical models of individual body movements from annotated mocap data to generate novel expressive animation suitable for dramatic performances. Based on an existing motion capture databse, we will train general action controllers for such actions as: sitting, standing, walking, grasping, taking and putting objects, in a variety of expressions and moods. In addition we will investigate learning animation models for new gestures and activities from only few training samples which will allow enriching the system easily by avoiding the costly and tedious task of gathering a large corpus of training data as usually required in statistical machine learning.

**WP2. Proxemic component: procedural animation models for interaction between actors.** Previous work on modeling proxemics has focused on the spatial positioning and orientation of conversational agents. Few researchers have looked at modeling agents with different personalities and social attitudes, which is an important aspect of dramatic performances. In this task, we will focus on simulating group of autonomous actors interacting with each other. To simulate the dynamic evolution of proxemic behaviors we will make use of Neural Network simulations. Mutual coupling of behaviors will be modeled as emerging from such action-reactive behavior simulation ensuring not only the synchronization between actors’ behaviors but also their mutual influence.

**WP3. Performance authoring and real-time execution.** This work package will elaborate a common conceptual framework for assembling all the behaviors, goals and animations of all actors into a coordinated, real time performance. Authoring of performances will be based on traditional cue sheet, which are familiar to theatre directors. Cue-sheet are multi-modal documents consisting of « blocking notations » written in a pseudo-natural language of verbs and adverbs, together with a graphical annotation providing spatial and temporal « cue signals » for all actor movements. Internally, we will compile the cue sheet into a hierarchical finite-state machine, which is a de-facto standard in real-time game engines. Depending on their current states, virtual actors will update their positions, orientations and gaze directions using behaviors from WP2, and their other animation parameters using statistical models from WP1.

**WP4. Evaluation and validation.**  Using the autonomous digital actors from WP1, WP2 and WP3, we will create short theatre scenes covering the spectrum of actions and emotions covered by the project. The directorial constraints will be adapted to the research scope in order to guarantee expressive results matching creative issues. Evaluation and validation will include short staged performances by the virtual actors, demonstrating both the quality of the animation and the usability of the user interface.

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The general public has become familiar with « virtual movie actors » whose performances are in fact exact reproductions of human actors recorded with motion capture devices. Despite much research work on autonomous agents, believable characters and multi-agent simulations, there is curretnly no such thing as a virtual actor, i.e. a software agent capable of generating a plausible and expressive performance of a dramatic play script.

The DADA project will contribute to this important scientific and technological challenge by leveraging knowledge in building dramatic performances from theatre studies and practices, and applying this knowledge to virtual performances. New statistical and procedural methods for character animation will be integrated in a unique software environment, focusing entirely on the core problem of generating expressive and believable actor performances under a director’s control. Virtual theatre productions will be used to showcase the expressive power of the blocking notation developed by DADA, the quality of its animation, and the usability of its authoring tools.

Creating plausible and expressive virtual actor performances without motion capture is also a major challenge for the video game industry, which is one of the leading creative industries in France, with success stories include the number-two world leader Ubisoft and the innovative independent developer Quantum Dream.

The expected results of DADA will be (1) a **virtual theatre company of autonomous actors** with a large vocabulary of expressive animation skills; and (2) a **prototype system** for directing arbitrary dramatic plays, amenable to a variety of digital storytelling applications.

Those results will be integrated into the Unity3D game engine, which is already used by the GRETA platform at Telecom ParisTech and the virtual cinematography framework developed by the IMAGINE team at Inria. Results will be used by Paris 8 as a virtual rehearsal space for theatre productions involving real actors interacting with digital actors, and as a platform for publishing digital dramatic performances online. If applicable, results will also be patented and exploited by the three academic partners, targeting commercial applications such as video games, digital storytelling, virtual worlds and movie previz.

At the end of the project, the toolset developped in DADA will be made available publicly as an open source project serving as a platform for the development of the next-generation of non player character (NPC) in video games, and for supporting virtual and augmented theatre productions.

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