I N R I A

Team MIRAGES

Object Manipulation in Image Sequences for Augmented Reality and Special Effects

Rocquencourt

THEME COG

Activity

Report

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2. Overall Objectives

2.1. presentation

The MIRAGES project research activity is concentrated on the manipulation of 3D objects in images sequences and its application domain is oriented towards new services (related to those 3D objects) which will appear in future communication networks. Research activity is carried out in two directions:

2.1.1. First Research activity: 3D Analysis of image sequences

We are interested in the determination of properties such as structure, movement and photometry of 3D objects in image sequences. Our approach differs from traditional methods as we mainly look for feedback model-based methods to guide the analysis. The main problems we are handling are:

- 3D object tracking in image sequences when the geometry of the object is known but its movement has to be determined. Both rigid, articulated and deformable objects are considered: particularly human body and face tracking.

- Automatic and semi-automatic object model specification: starting from a generic model of an object(for example a human body or a face) and an image sequence, this task has to construct the specific model which will be used for tracking in image sequences (see above).

- Interactive, semi-automatic and automatic camera calibration: Here, we use 3D object models (very often, generic models) which are used as calibration tools, in order to perform calibration. Calibration is necessary for 3D model specification.

- Inverse rendering (Computer Graphics denomination corresponding to photometric analysis in Computer Vision): We dispose of input images of a scene and of a 3D geometrical model of this scene. The aim is to compute the photometry of the part of the scene available on those images in such a way that the digital synthesis of the scene model corresponds faithfully to the input images. The main application of this specific research is oriented towards the creation of advanced tools for audio-visual productions (advertising, films,...)

Collaboration is carried out with Mikros (a french post-production company) on the RIAM VIP3D contract which started in 2001. With VIP3D, we tackle human body tracking and specially face tracking for 3D rotoscopy in post-production. Golf-STREAM contract started in June 2002 in collaboration with the french Symah Vision production company. The task is to study complete human body tracking and more specifically professional golfers from image sequences in order to allow them to improve their technique and also enrich journalists comments for television broadcasts of professional golf tournements. We hope to extend this work to other types of applications such as video-surveillance, tele-conferencing, video games, while mixing real and synthetic images.

2.1.2. Second Research Activity: 3D Garment Simulation

The second research direction is the creation and deformation of soft objects, particularly non linear and hysteretic ones. Presently, our research activity is limited to the 3D simulation of garments. In this research area, we are mainly studying:

- The control of the mechanical properties of soft 2D structures (like textile materials) modelled by mass/spring systems.
- The automatic construction of garments from 2D patterns around a human body modelled as an articulated mechanical system.

Potential applications are the realistic synthesis of 3D garments on 3D numerical mannequins applied to future e-commerce of garments for the textile industry. We are looking for funding sources for this application.

3. Scientific Foundations

3.1. Augmented reality for TV productions: 3D human tracking

Keywords: *3D human modeling*, *3D tracking*, *anthropometry*.

Participants: Chee Kwang Quah, Dayue Zheng, Tsuyoshi Minakawa, André Gagalowicz.

A 3D model-based approach is applied to human body tracking for production and post-production applications.

We are currently developping a 3D tracking system using video cameras able to produce outdoor motion capture without the use of markers. A generic 3D human body is used as input. Then, body adjustments are made using images. After positioning the puppet on the first frame, the texture is learnt and a tracker has to retrieve the position of the puppet automatically in the rest of the image sequence.

3.2. Realistic face reconstruction and 3D face tracking

Keywords: *3D Face Modeling from Images*, *3D Face Tracking*, *Deformable Models*, *Model-Based modeling*.

Participants: Richard Roussel, Daria Kalinkina, Naima Houti, André Gagalowicz.

3D reconstruction of a realistic face model from a small set of images is one of the greatest challenges in the field of audio-visual post-production and special effects generation. Previously manual, tracking is more and more automated. We are working on faces, which are one of the most difficult entities to track, because of their slight deformations. In order to perform a high quality tracking, we developed a technique to model a 3D mesh of face from a set of images taken from a video sequence. This model, first constructed in a neutral expression, is animated for tracking purposes.

3.3. 3D garment simulation

Keywords: *constraints*, *mass-spring systems*, *numerical integration*, *spatial coherence*.

Participants: Hatem Charfi, Le Thanh Tung, Jeremy Denise, André Gagalowicz.

3.3.1. Mechanical modeling of textile materials

Usual geometric modeling is not sufficient to simulate cloth: an in-depth knowledge of fabrics behaviour is required. Relations between stress and strain have to be delt with, that are not defined by ordinary differential equations. Since analytical solutions are not available, numerical models are used; we have chosen mass-spring systems.

These models have to be fed with correct parameters. The Kawabata Evaluation System is the de-facto industry standard for fabrics measurements (limited to warp/weft textile materials): it operates typical deformations upon cloth samples and evaluates the resulting stress, which is provided as digital data. Our textile models are now able to simulate precisely Kawabata curves of real textile for tension, shear and bending.

3.3.2. Dynamic cloth simulation

Once a numerical model of cloth is stated, our goal is to compute its evolution with respect to time; it relies on the integration of the fondamental equation of dynamics. Several families of algorithms exist, adequations to the underlying problem of which, vary both in terms of stability and computation time. Check of the validity of our approach is a very strong challenge that we began to undertake.

Handling contact phenomenon between pieces of cloth, and the characters that wear cloth is the other big challenge: large amount of data have to be processed to accurately detect possible collisions, and a realistic model has to be used once an actual collision has been detected.

4. Software

4.1. Emilion

Emilion is the cloth simulation system that was developed by J. Denise during his Ph.D.

This software computes the evolution along time of garments that are represented by mass-spring systems. Both explicit and implicit integration schemes are available. Hysteretic behaviour is taken into account in order to reach a high degree of realism. Contact and inverse kinematics are introduced through the constraints handling method initiated by Baraff. An attractive feature is the spatial partitioning scheme that makes collision detection a low-cost task, even with large scenes (less than 15 % computation time in typical simulations).

Emilion was written in C++ and makes heavy use of Generic Programming concepts (which most famous incarnation is the Standard Template Library). Tcl was chosen as its scripting language to ease both its feeding with external data and the simulation of Kawabata [4] experiments.

An extended version was developed by D. Reversat to allow draping on animated characters.

5. New Results

5.1. 3D Human tracking

Participants: Chee Kwang Quah, Dayue Zheng, Tsuyoshi Minakawa, André Gagalowicz.

5.1.1. Introduction

We are targeting the problem of how to track in 3D a human body captured with several video cameras in order to reduce the cost of post-production by making it *almost* automatic.

Our algorithm is composed of the following five steps:

1. Calibrating camera parameters and making a customized surface model under the condition that captured images, a generic surface model, and correspondence of their feature points are given.

2. Refining the customized surface model and making a customized skeleton model under the condition that the silhouettes of the human body in the input images are given.

3. Pre-positioning the customized 3D models so as to fit them to the first frame images.

4. Mapping textures onto the pre-positioned surface model.

5. Tracking the human body in a video sequence using a certain skinning function and the customized 3D models with texture learning.

The former two steps had already been established since the previous period, therefore we studied the latter three steps in this period.

5.1.2. *Human body pre-positioning*

The third step described above can be solved in full-manual way using some 3D modeling software. However, the people in the field of computer vision are not familiar with handling of those kinds of software, and the people in the field of computer graphics are not familiar with the thinking ways of computer vision.

Therefore, in order to make this step easier to everyone, a program is being implemented with an approach that uses the customized 3D models and the first-frame images to make the pre-positioning procedure semi-automatic. This topic is now ongoing.

5.1.3. *Skinning and Tracking*

In order to make up the fourth and the fifth steps described above, which have to be operated automatically, we will need to find a good skinning function to obtain a good estimation in frame-by-frame operations, and need to know in the viewpoints of both tracking quality and computational time, the minimum number of control points, the minimum DOF at each of those control points, and how to obtain helps from GPU to accelerate calculations.

As preparations for these, some reviews and some implementations about these topics were done in this period of time. These topics are also now ongoing.

Practically, we want to generate of 3D golf-playing animation based on six sequences of captured video in different views.

The former research has generated a static 3D model from six captured images which is such that its projection coincides with the images of the golfer on the video. The 3D model contains a 3D skeleton model inside. The first step of the work is to define a joint structure for the 3D skeleton allowing the control of the human body movements. The bones of the 3D skeleton model are rigidly bound to the joint structure and the skin of 3D model has to be bound to the 3D skeleton. The second step consists in determining a skinning function which relates each vertex of the 3D body shape to a (or several) point of the 3D skeleton. Test of quality of the joint structure and of the skinning function will be validated by interactive pre-positioning of the 3D skin from a stanza position to the initial position of the golfer's swing. A successful result can be seen on figure 1.

5.2. Realistic face reconstruction and 3D face tracking

5.2.1. *Development of software for 3D face modeling*

Participants: Naima Houti, André Gagalowicz.

For our postproduction project, we had to implement software for 3D face modeling. This job was performed by a former PhD student, but implemented as a plugin in the Maya software. Because of the complexity of coding under Maya, a new implementation outside this software was necessary to permit the evolution and the improvement of our application. The 3D face modeling software works as follows :

- Having as inputs a generic model 3D model of face and a set of face pictures taken from different view points.

- Create cameras in a 3D world putting the photos in the corresponding image planes so as to simulate the way the pictures were taken (see Figure 2).

Figure 1. 3D human model.

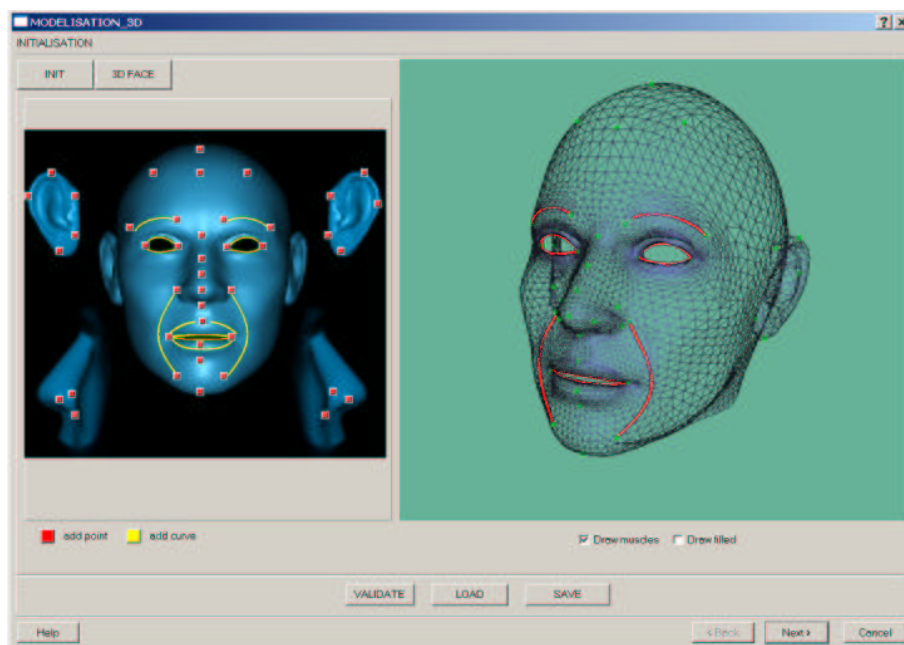*Figure 2. Step of manual calibration of the cameras*

Figure 3. Determination of feature points in the generic model

- Define feature points in the 3D model and their corresponding 2D points in each picture. This is done manually by the user. For instance, we select the extremity of the nose in the 3D model and we indicate in each picture the place we find the extremity of the nose (see Figure 3).

- The feature points are modified in order to put their projections in image planes to the same place as the 2D points previously defined.

- Then deformation is interpolated to the rest of the mesh vertices.

- The modifications are made iteratively alternating camera calibration and mesh deformation till convergence (see Figure 4).

Figure 4. Determination of feature points in the specific model

- Since the number of interesting feature points is limited (extremities of the eyes, extremities of the mouth ...) some face regions remain unchanged by the point based adaptation (the chin form for example). So we used a limb adaptation method that consists of drawing Bezier curves around the limbs on the images, and try to deform the mesh to make its projected limbs correspond to the Bezier curves position. This has given very satisfactory results ! (see Figure 5)

5.2.2. 3D face tracking implementation

Participants: Daria Kalinkina, André Gagalowicz.

Having developed 3D face tracking algorithm as a plugin to Alias Maya software we've also implemented it as a stand-alone application using only OpenGL and QT-interface. Our tracking algorithm is based on the usage of the 3D model of the person for detecting the location and the facial expression of this person on a number of successive images. In initialization step the 3D model is textured by the first image of the sequence. To do this the model is manually prepositioned and given the proper facial expression in order to fit the face on the first image. After that the tracking process is launched for every image of the sequence. It is based on the minimization of the error between the projected textured model and the face on the image. New application

Figure 5. Adaptation of the model limbs (in red) to the Bezier curves (in green)

provides the same results as the Maya plugin (Figure 6, 7) but performs faster processing due to the usage of the specific OpenGL features (p-buffer) and the fact that Maya re-evaluates the complete scene during rigid tracking as well as during tracking of expression, while in the rigid case only recalculation of the vertices projections is needed. Thus OpenGL implementation allowed us to make rigid tracking 6 times faster than in Maya.

5.2.3. *Realistic face expression modeling and tracking*

Participants: Richard Roussel, André Gagalowicz.

5.2.3.1. *Realistic face reconstruction*

Our realistic face reconstruction requires only a small set of uncalibrated images showing the same face under different points of view, and the use of a generic model, that is deformed in two steps. In the first step, the deformation of the generic model is performed using 38 characteristic points that are related to the face anatomy. An iterative technique involving camera calibration and 3D computation of the face characteristic points is performed to find the real 3D locations of each point on the specific face. A Radial Basis Function (RBF) technique propagates the deformations resulting from the displacement of the characteristic points on every vertex of the 3D model. In the second step, the silhouettes of the 3D face model are, in turn, matched to those of the real face, on images. The additional control of the silhouette curves gives much more information that allows more faithful reconstruction of faces. The technique has been applied very successfully to many different human faces, even with very caricatural faces.

5.2.3.2. *Validation of the reconstruction technique*

The validation of the method has been carried out with the use of a synthetic face, the 3D geometry of which was available. 3 images (from 4 used) of this synthetic face are shown in figure 8. The initial error (in cm) between the generic model and the real one to construct is displayed on figure 9.a . White corresponds to the maximum error and dark to zero for the various vertices of the model to construct. In figure 9.b, we see the
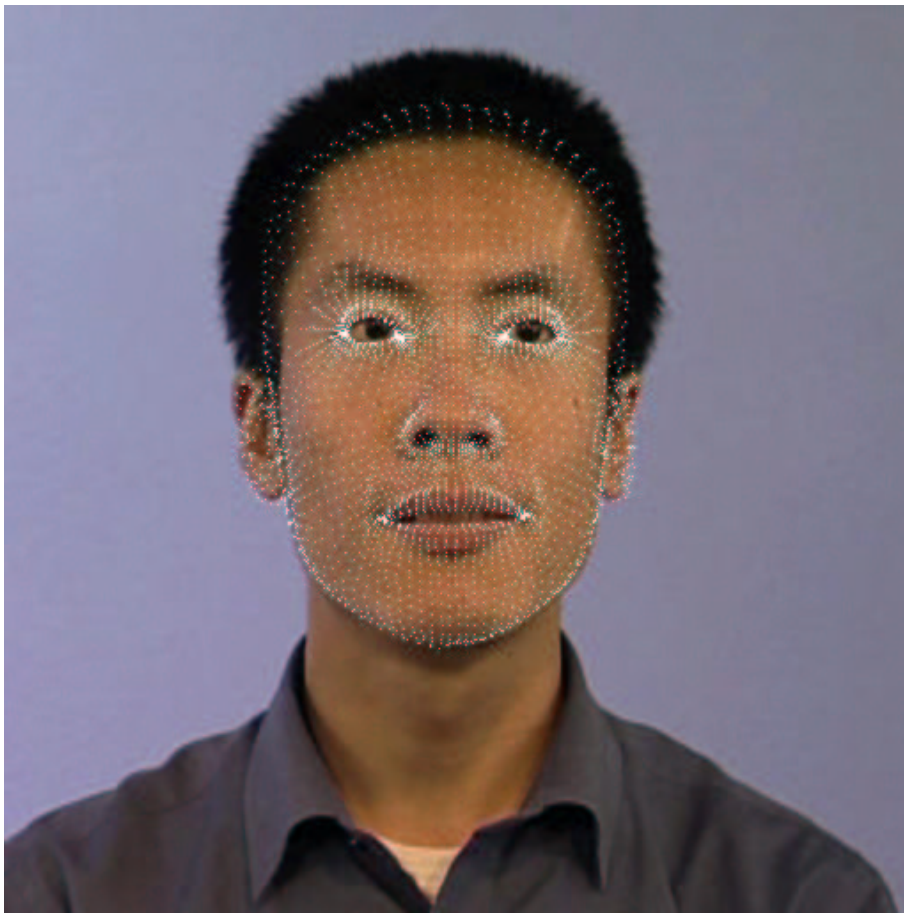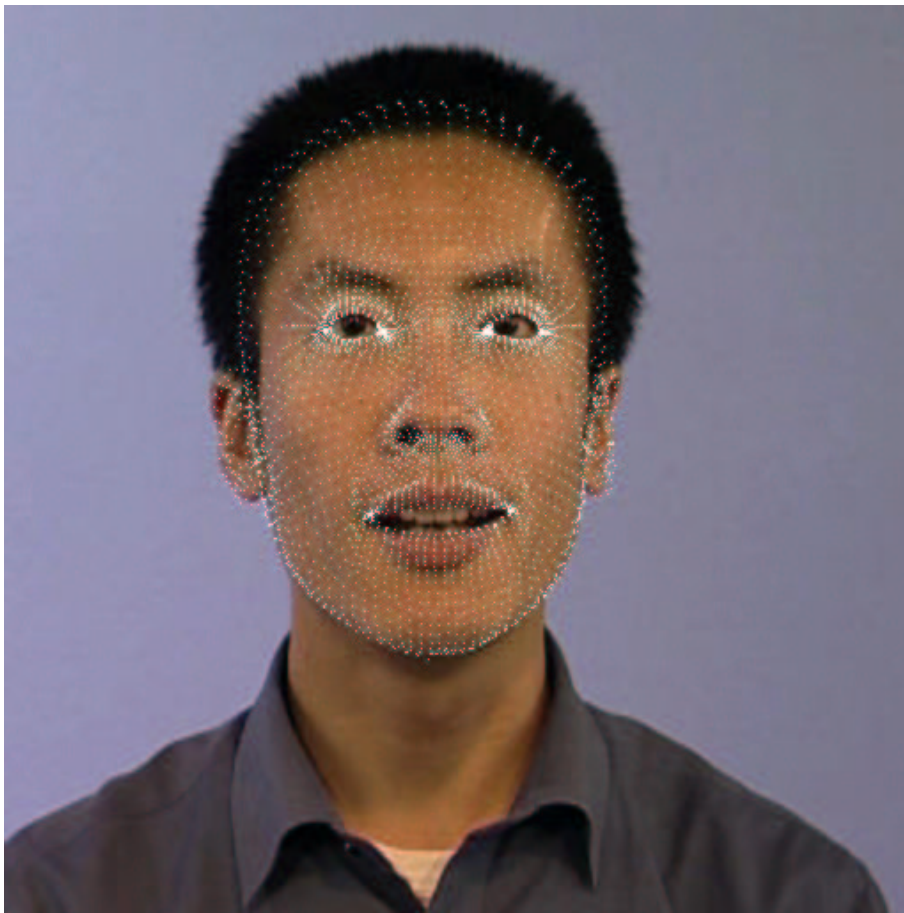
Figure 6. Frame 2

Figure 7. Frame 20

new error when the control of our 38 feature points has been used. In figure 9.c, the control of one silhouette is added. In figure 9.d, two silhouettes are controlled and in figure 9.e, all (4) silhouettes are used to control the deformation. It is easy to see the continuous improvement of the method. The average error (in cm also) is also displayed beneath each error image. It is 0,837 cm initially and is reduced to 0,278 cm for a face that is roughly 25 cm large. We had similar types of errors for all the examples tried with the use of only four silhouettes. The final reconstruction error is of the order of 1/100 which is roughly the precision reached by conventional laser systems. This proves that this new type of reconstruction is faithfull, quick and does not require any hardware except a cheap camera.
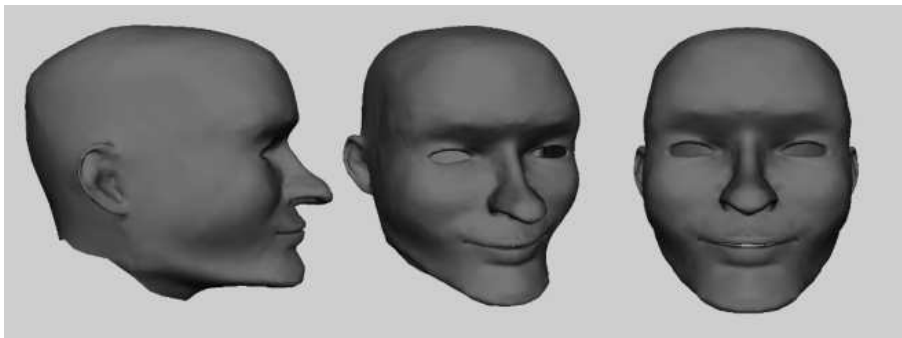

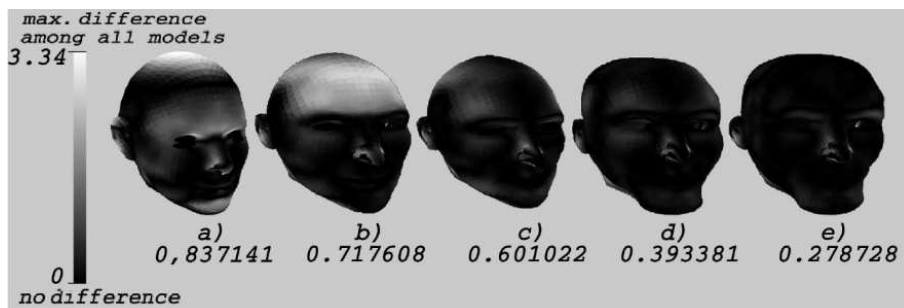*Figure 8. The 3D model used to validate our method.*

Figure 9. Reconstruction error between the 3D model, and the generated one.

5.2.3.3. Facial Tracking

Given the specific 3D model built in the previous section, we can now use it to track the face of the reconstructed person in a movie. In fact, we're using an analysis / synthesis loop in order to determine the exact position and rotation of the 3D textured mesh over a image (see figure 10 and 11).

In order to improve the face tracking, we have developed a muscle model, allowing us to deform the face as muscles do. We learnt how each muscle was deforming the skin, and the eyes. We saw that each action of the face (smiling, rising the eyebrows, etc.) comes from a combination of several muscles. Our muscle model is a hierarchical model with, at the highest level, a set of 14 behaviors (rise the upper/lower lip, close the left/right eye, etc.). The tracking algorithm has to consider each behavior as a degree of freedom of the system, in
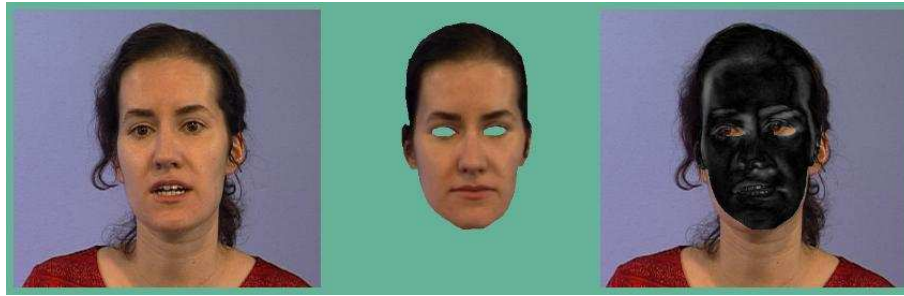
Figure 10. A bad position and rotation of the 3D textured mesh (in the center image) over the original image (the left one) gives a big matching error, in the right image.

Figure 11. A good position, and facial expression give us a very low matching error, in the right picture.

order to find the best vector, in the behavior space, to represent the face. This algorithm minimizes the pixel-matching error between two images. The first image is the original image, in which we want the tracker to work, and the second is a rendering of the textured model, according to a particular face vector, translation and rotation. The method searches the translation and rotation of the 3D model and, in a the behavior space, the best vector that makes the smallest difference between the original image, and the synthetic image. When done, we have found not only the face position and rotation, but also the facial expression. Some results are given in figure 12.

Figure 12. Two snapshots of our tracking, in a talking sequence, on the left, and in a smiling sequence, on the right.

5.3. Study of fabrics

Research on cloth animation and computer generated garments is a field of major interest among both computer graphics and textile research communities. The most common approach is to model cloth objects using mass-spring systems and to resolve Newton's equation governing the system motion using implicit integration methods. Unfortunately, results lack usually of realism.

5.3.1. *Virtual cloth pre-positioning*

Participants: Le Thanh Tung, André Gagalowicz.

We want to develop a virtual dressing system which can be used easily by a normal user who can try garments using some very simple actions. In this paper, we will present a 2D manipulation method which will be coupled in the future to a 3D mapping technique allowing to reach the final pre-positioning required.

Our system starts with a generic 2D silhouette model that is to be dressed. The two figurines (showing the front view and the back view) of the future garment are either provided by the garment designer or will be selected from a database. The use of the generic silhouette and the figurines allows the designer to specify naturally in 2D how the various patterns will appear on the front and the back of the puppet when the garment will be on the puppet. The figurines have to be placed over the generic silhouette. After specifying the sewing informations on the figurines interactively, the designer will have finished his work which will be done only once for a specific garment. We have also to create an easy-to-use interaction software to provide to the designer. The remaining task will consist in deriving these informations when we replace the generic silhouette by the silhouette of a future client. This task will have to be automatic and will give the future front view and back view of the client wearing the garment.

5.3.1.1. Input data

Our system uses a 3D human model as input data. An acceptable model has two extended arms. The angles between these extended arms and the body should be large enough so that there will be no collision when the

garment will be added to the silhouette. In our work, we start with a normalized 3D human model which will serve as a generic silhouette for the designer.
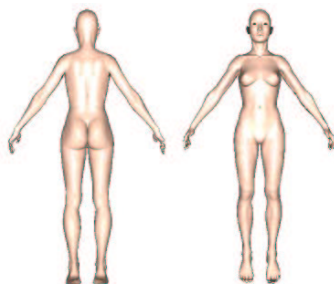

Figure 13. 3D human model

Figure 14b presents a real very simple garment imported from a DXF file. It contains some holes corresponding to garment darts. In order to simplify the digitization, we need to suppress the holes. This can be done by simply creating two virtual cuts (we do not see them) from the hole to the garment bound. The line cutting direction is selected by the user (figure 14a). The sewing information of the 2D patterns is provided by the designer, who will specify how two patterns are sewn together (sewing type, direction ...).

Figure 14. Figurines and garments

2D figurines (front and back) are used as key elements in our method (14c, 14cd). The figurines should be provided with the garments or be selected from a database. In general, some clothes can use the same figurine, if they are from the same kind and design type (shirt, trousers or skirt of various sizes ...).

5.3.1.2. 2D Manipulation

We developed software to do the pre-positioning. Figure 15a shows how the program works. We can see a list of 2D patterns in the left panel. Each 2D pattern has its own name (number by default or named by the designer). The 2D pattern selected by the user is shown in work space. After an editing stage (correcting the contour, dividing 2D pattern to create new virtual 2D patterns ...), the 2D pattern will be assigned to the correspond one in the figurine (front or/and back). In addition, we set a specific color for a segment type (green for a virtual, red for a real and purple for a free segment). Figure 15b shows how to edit a figurine to adapt it to the generic silhouette. In this case, the segments of the figurine are marked as assigned (yellow). The designer moves segments or/and control points to perform this task.
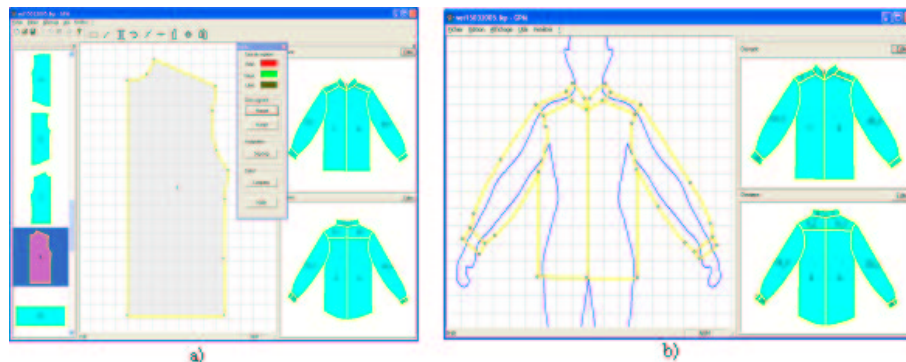
Figure 15. Designer interface of Virtual Garment Pre-positioning program, a) editing a patron; b) editing a figurine

5.3.1.3. Validation of Figurines mapping

Figure 16 shows the result of using 2D mapping from the generic to the real silhouette. The green curve represents the generic silhouette, the red curve comes from the points mapped onto the real silhouette and the blue curves show the differences between the mapped points and the real ones. From this result, we can show that this mapping performs a correct task. Figure 17 shows some examples of our final garment pre-positioning results. With different poses, the figurine is automatically positioned onto the model.
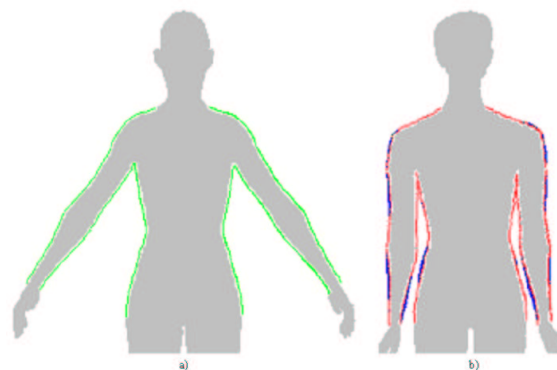
Figure 16. Validation of the 2D mapping a) Standard silhouette; b) Real silhouette

5.3.1.4. 3D Transformation of 2D garments

We transform the figurine from the real silhouette to the final 3D reconstruction around the 3D mannequin (see figure 18 and figure 19).

5.3.2. *Study of fabric viscosity*

Participants: Hatem Charfi, André Gagalowicz.

Improvements in the mechanical precision and realism of cloth simulation can be done by measuring the viscosity of fabric in order to compute precisely parameters of damping models. An experiment was carried

Figure 17. Various examples of the mapping with different poses

Figure 18. 3D recontruction of a shirt

Figure 19. Final result with texture

out in collaboration with ATTITUDE-STUDIO using a MOCAP system in order to measure precisely the energy damping during the movement of fabric.

5.3.2.1. How is it done ?

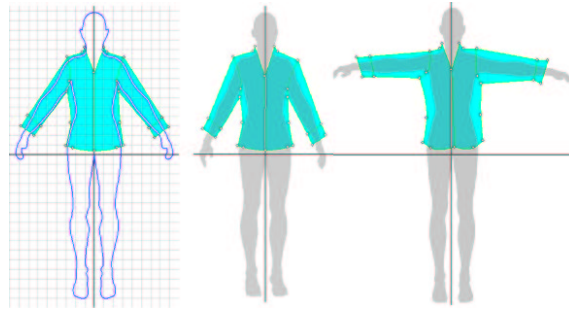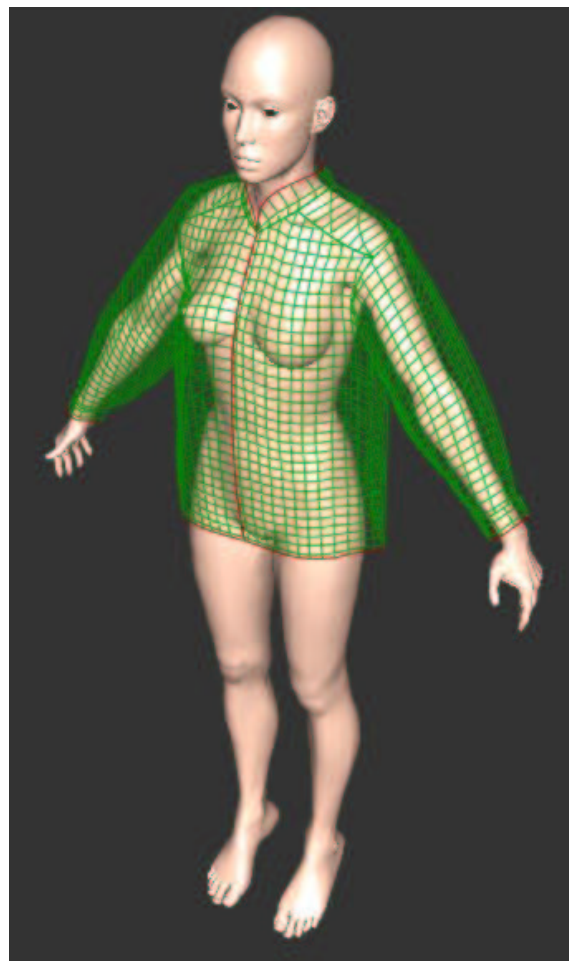The experiment performed in collaboration with ATTITUDE-STUDIO consists in dropping a piece of fabric in free fall and measuring its trajectory using a motion capture system (MOCAP) (see figure (20) for the setup).
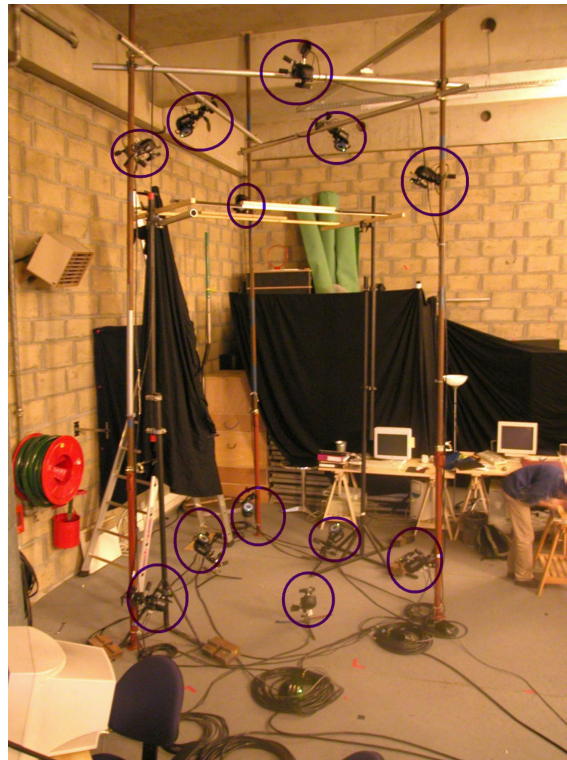
Figure 20. 12 cameras of the Motion Capture System (MOCAP)

We model fabric (limited to warp and weft textile materials) using a mass-spring system (Provot 1995). Thus, cloth is approximated with a quadrilateral mesh of particles. Various types of springs are used to connect masses to each others. There are three types of springs :

- Tensile springs : connect two neighbor masses in the warp (or weft) direction.
- Shearing springs : connect two neighbor masses in the diagonal direction to the warp (or to the weft).
- Bending springs : connect four masses forming two adjacent facets.

The tensile and shearing springs forces are in the plane of the fabric, whereas the bending springs forces are orthogonal to the plane of the fabric.

These springs have to be fed with correct parameters to meet the realism that we look for simulation.

The Kawabata Evaluation System (Kawabata 1980) is widely used as the industry standard for fabrics measurements (limited to warp and weft textile materials): it operates typical deformations on cloth samples and evaluates the resulting forces, which provide us with the parameters to put on the springs.

5.3.2.2. Damping Model

The damping model used is the Rayleigh damping model. Its mathematical formula is :

$$[C] = \alpha[M] + \beta[K] \tag{1}$$

where $[C]$ is the damping matrix (n x n), $[M]$ is the mass diagonal matrix (n x n), $[K]$ is the stiffness matrix (n x n), α and β are the damping constants, and n is the total number of masses used to model the fabric. However, our mechanical model uses 3 different types of springs. So, the stiffness matrix $[K]$ is decomposed as the sum of 3 stiffness matrices.

$$[K] = [K_b] + [K_{sh}] + [K_t]$$

Equation (1) becomes :

$$[C] = \alpha[M] + \beta_b[K_b] + \beta_{sh}[K_{sh}] + \beta_t[K_t]$$

The linearity of Rayleigh's model makes it possible to derive the equation above. The computation of the 3 constants β_b, β_{sh} and β_t allows the computation of the damping force for each spring type. The determination of the constant α allows the computation of damping produced by the movement of masses in the air, i.e. the viscous damping between the fabric and the air. The total damping force is :

$$F_{damp} = [C]V$$

where V is the velocity vector of all masses.

5.3.2.3. Experimental setup

A sample of 50cm by 50cm of a fabric (woven in warp/weft) is cut. Reflective round markers are stuck on both sides of the fabric in order to form a regular grid. Then, the fabric is thrown in a free fall and the MOCAP system starts recording the successive positions of the markers (see figure (21)).

5.3.2.4. Results

The viscous parameters are then obtained by the adjustment of the simulated trajectory of this fabric computed by our simulator, to the real trajectory. We tried first to use global minimization in order to compute the best damping parameters that fit our data.

$$\text{Let } F_{error} = [M]A - [M]g - F_{springs} - F_{damp}$$

where $F_{springs}$ is the springs total force on masses. Damping parameters are obtained by minimizing the norm of F_{error}.

$$\Phi(\alpha, \beta_b, \beta_{sh}, \beta_t) = F_{error}^T . F_{error}$$

$\Phi(\alpha, \beta_b, \beta_{sh}, \beta_t)$ is a definite positive quadratic form, so we can find its minimum by computing its partial derivatives and making them equal to zero. We obtain a linear system.

$$M \begin{pmatrix} \alpha \\ \beta_b \\ \beta_{sh} \\ \beta_t \end{pmatrix} = b$$

We could compute the conditioning number of matrix M to evaluate the solution stability using :

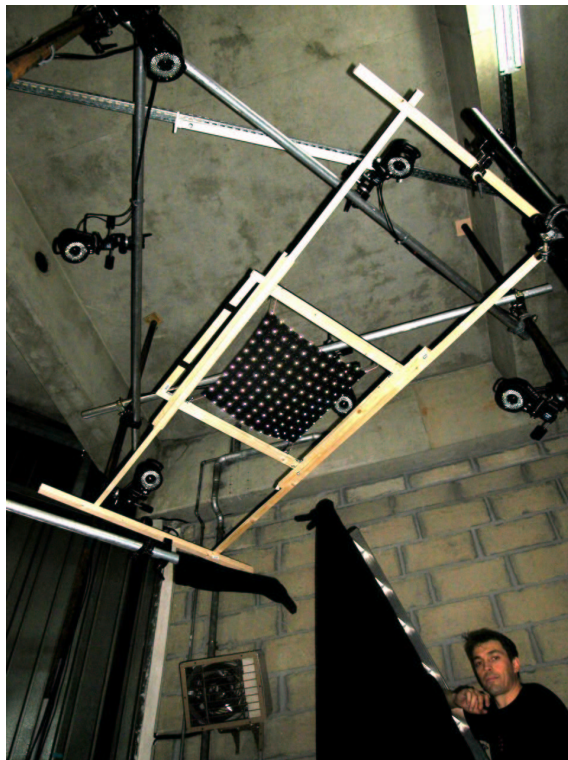$$\kappa(M) = \parallel M \parallel . \parallel M^{-1} \parallel$$

Figure 21. A sample of fabric with reflective markers

$\kappa(M)$ can also be computed as the ratio between the greatest eigenvalue and the smallest one, since M is symmetric definite positive.

The diagonal terms of M are "proportional" to the square of the damping forces corresponding to air viscosity, bending, shear and tension which have sequentially values with an order of magnitude greater than the previous one. So, M is a largely diagonal dominant matrix and its determinant can be approximated by the product of its diagonal elements. So :

$$\kappa(M) \geq \frac{\frac{trace(M)}{4}}{\sqrt[4]{det(M)}} \gg 1$$

We notice that the conditioning is very large, so the system is ill-conditioned and the solution will not be stable. Thus, we propose to compute damping parameters using iterative minimization.

Using the optimized parameters found, we can evaluate the improvement of the simulation.

We can first compute the error force without taking into acount damping $F_{error}^{without-damp}$ at each step of the identification, and compare it with $F_{error}^{with-damp}$.

The results are summed up in tables 22 and 23.

	α		β^{bend}		eta^{shear}		$\beta^{tensile}$	
	mean	std	mean	std	mean	std	mean	std
fabric 11	-7.0	1.9	-6.8e-3	2.0e-2	-3.1e-4	2.9e-4	-3.9e-6	4.2e-6
fabric 12	-5.9	2.4	-5.2e-3	1.5e-2	-4.0e-4	4.0e-4	-2.7e-6	3.0e-6
fabric 13	-7.2	2.2	-3.1e-4	2.0e-3	-1.8e-4	4.6e-4	-4.0e-6	5.3e-6
fabric 21	-7.2	2.3	-2.0e-4	5.7e-4	-4.3e-4	6.7e-4	-4.6e-7	5.7e-7
fabric 31	-7.4	1.1	-8.4e-4	3.1e-3	-1.1e-3	6.1e-4	-2.2e-8	6.0e-8

Figure 22. Damping parameters

	α	β^{bend}	β^{shear}	$\beta^{tensile}$
	error decrease	error decrease	error decrease	error decrease
fabric 11	50%	0.3%	3%	9%
fabric 12	45%	0.3%	1.1%	6%
fabric 13	51%	0.1%	1.4%	3.3%
fabric 21	48%	0%	2.3%	0.5%
fabric 31	72%	0.2%	36%	0.8%

Figure 23. Error decrease using optimized parameters

Our work gives the possiblity to compute experimentally these parameters and to measure their numerical and visual contribution for the simulation.

In the figure (24), the yellow fabric is the real trajectory and the green is the simulated one.

It is clear that the real trajectory and the simulated one are very close which validates our approach.
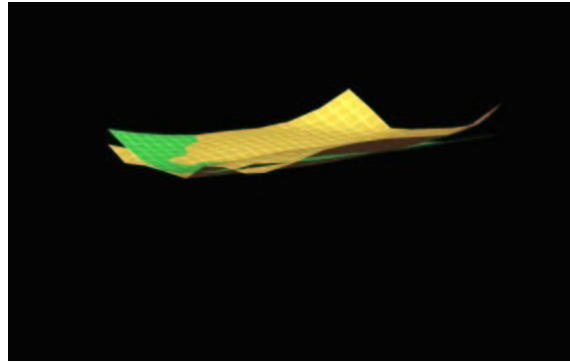
Figure 24. Comparaison between the real fabric (yellow) and the simulated one (green) falling down

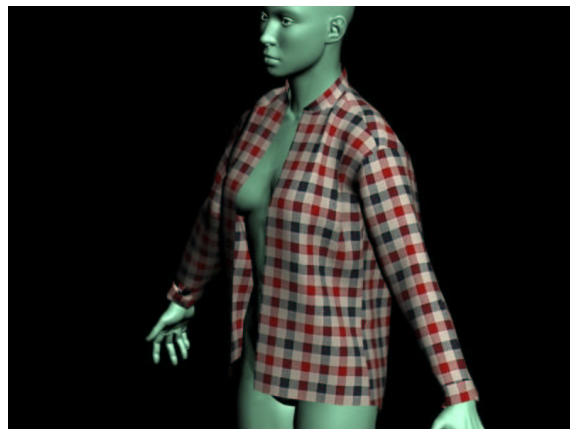
Figure 25. Virtual cloth 1/3

Figure 26. Virtual cloth 2/3

Figure 27. Virtual cloth 3/3

5.3.3. Garment simulation

The previous results on viscosity measurements have been used in order to produce realistic garment images. This work has been done using a new technique for cloth pre-positionning. (see section 5.3.1 and figures 25, 26 and 27).

The fabric used is the fabric 11 (see previous section dealing with viscosity).

5.3.4. Recovering cloth mechanical parameters from uncalibrated images

Another field of research that is worth exploring is recovering mechanical cloth parameters from uncalibrated images. In fact, it is not possible to make Kawabata measurments all the time, or it will take very long time to do such measurments since the Kawabata machines are very expensive and their use requires some technical experience. The idea consists in taking pictures of a piece of fabric in a "simple" position (e.g. draping on a table). Then, we specify the feature points of the model on the images. We use a calibration-reconstruction algorithm in order to obtain the caracteristics of the camera and the 3D shape of the fabric. finally, using a simulated annealing minimization, we obtain the mechanical parameters of the fabric that we can use again in the simulator to obtain realistic 3D cloth.

Figure 28. fabric draping with feature points

6. Contracts and Grants with Industry

6.1. Golf-Stream

Participants: Chee Kwang Quah, Dayue Zheng, Tsuyoshi Minakawa, André Gagalowicz.

The Golf-Stream project of the Riam (Research and Innovation in Audiovisual and Multimedia) network is interested in movement capture on a real life character. This is a complex problem that we are solving by adjoining INRIA's skills with those of the Symah Vision production house. PGA (professional Golfer association) and FFG (French Federation of Golf) are part of that project in order to drive the golf analysis.

MIRAGES develops a tool that makes it possible to capture actual movements of a golfer on site. In an initial stage, static images of the player are shot from different angles and are used to reconstruct his or her skeleton and body envelope. The virtual character will then be superimposed live over the player in action and will adjust itself to the player's body with few interaction. Software can determine body movements (pelvis rotation, arms position, etc.) as well as the position of the player's center of gravity and direction imposed to the ball with great precision. This method does not require the use of sensors placed on the athlete's body. However to obtain a result on a sequence, we optimized the software to be much faster and usable by TV crews.

Standard video cameras are able to provide up to fifty images per second. It is thus possible to broadcast a slow-motion sequence showing the superimposed skeleton of the player with added visualization tools that support live comments on such and such aspect of the shot, barely a few minutes after the shot. This product should be available for TV broadcasts in the future.

Golf-Stream is now under the MIRAGES Coordination.

6.2. VIP3D

Participants: Richard Roussel, André Gagalowicz.

This contract is an application of our research for post-production and is conducted in collaboration with MIKROS IMAGE. This contract follows two european MULTIMEDIA ESPRIT contracts : NEMESIS I and NEMESIS II where the target was to produce commercial software for the 3D rotoscopy of rigid objects. This software is now available under the name of FROGPLUGS. In VIP 3D, we generalize the former technique to the case of deformable objects. Practically, we reduced research activity to the study of human face tracking for 3D rotoscopy.

6.3. Attitude Studio Partnership

Participants: Hatem Charfi, André Gagalowicz.

This contract is an application of our research on 3D garment simulation. The idea was to put together ATTITUDE STUDIO expertise on the design of realistic human avatars, and the expertise of MIRAGES on 3D garment simulation in order to produce a realistic avatar (EVE SOLAL) wearing realistic garments.

Attitude Studio's computer graphists provided us with a 200 frames animation of their own virtual "star" : Eve Solal. This allowed us to perform our first test with dynamic environment on our simulator and thus to improve and validate it. Then we prepared several videos of Eve with different clothes that where submitted to Attitude's computer graphists opinion (see figure 29).

Hatem Charfi has performed his study on fabric viscosity using the MOCAP system gently made available by Attitude Studio (see figure 20). This colaboration allowed us to improve considerably the performance of our garment simulation software (See section 5.3.2)

Figure 29. Eve with a dress

6.4. NADINE CORRADO

Participants: Tung Le Thanh, Hatem Charfi, André Gagalowicz.

Nadine Corrado is a Fashion Creator; we collaborate on the validation of our 3D simulation of garments software; She is a potential end-user and also brought us a lot of information about garment conception.

6.5. C-DESIGN

Participants: Tung Le Thanh, Hatem Charfi, André Gagalowicz.

Collaboration on the design of software for 3D fashion

7. Other Grants and Activities

7.1. International collaborations

- Collaboration with XID Technologies, a company located in Singapore. André Gagalowicz is scientific advisor for the company.
- Collaboration with NTU (Nanyang Technological University) has been initiated. A PHD student Quah Chee Kwang is supervised by both A. Gagalowicz from Mirages and Seah Hock Soon from NTU.

7.2. Invitation of foreign researchers

- Quah Chee Kwang from NTU was invited from the 1st of November 2004 until the end of March 2005.
- Mikael Keckeisen from Thûbingen University, Hans Peter Seidel from Max Planck Institute, Thomas Vetter from Basel University, Reinhardt Koch from Kiel University, and Radek Grzeszczuk from Intel were invited each of them for a week stay at Mirages.

8. Dissemination

8.1. Animation of the scientific community

- André Gagalowicz was scientific advisor at the ESIEA Recherche.
- André Gagalowicz was scientific advisor at the INSA Lyon Scientific Committee.
- André Gagalowicz was scientific advisor at the University of Bordeaux III Scientific Committee.
- André Gagalowicz was member of the scientific advisory board of "Machine, Graphics and Vision", "Computer Graphics and Geometry" journals as well as of the LCPC journal.
- André Gagalowicz was scientific advisor of XID Technologies, Singapore.
- André Gagalowicz was invited by the Senat to Tremplin Recherche meeting to present Mirages activities to the public on the 8th of February 2005.
- André Gagalowicz was invited by the Senat to the Cercle Beaumarchais meeting on the 29th of September 2005.
- André Gagalowicz was invited by the Senat to the journée Science, Bien-être et Ethique, la martingale du Luxe meeting to present Mirages activities to the public on the 14th of November 2005.
- André Gagalowicz was a member of the scientific committee at the defense of Olivier Chassagneux at the Ecole Centrale de Paris, France on the 4th of July.
- André Gagalowicz presented the Mirages Research during the Hitachi visit at Inria on the 6th of July 2005, and during the INRIA-INDUSTRIE meeting in Rocquencourt on the 1st of February 2005.

8.2. Conference program committees and revue in Computer Vision and/or Computer Graphics

André Gagalowicz was a member of the conference program committees of:

- Mirage 2005 conference in Paris, France.
- CAIP 2005 conference in Paris, France.
- Graphikon 2005 conference in Novosibirsk, Russia.
- VVG 05 conference in Edinburgh, Scotland.
- ACVIS 2005 conference in Gent, Belgium.
- Eurographics conference in Prague, Tchekia.

André Gagalowicz was invited by NTU and XID technologies in Singapore from the 20th of March until the 4th of April, at Basel University (Professor Thomas Vetter) on the 6th of December.

André Gagalowicz has presented an invited paper at:

- Graphikon 2005 in Novosibirsk.
- VVG 05 in Edinburgh.

8.3. Conference Program Chair

- André Gagalowicz was the chairman of MIRAGE 2005 in Paris, France.
- André Gagalowicz was the chairman of CAIP 2005 in Paris, France.

8.4. Teaching

- André Gagalowicz has taught Computer Vision in the DESS on images of the University of Bordeaux III.
- Hatem Charfi has taught Java Programming in the first year undergraduate courses (DEUG MASS) at the university Paris 9 Dauphine..

8.5. Participation to seminars, conferences and invitations

- Hatem Charfi and André Gagalowicz published a paper in the Mirage 2005 conference (Paris) [13].
- Hatem Charfi and André Gagalowicz published a paper in the ISC 2005 conference (Berlin) [14].
- Hatem Charfi and André Gagalowicz published a paper in the CAIP 2005 conference (Paris) [12]
- Tung LE THANH and André Gagalowicz published a paper in the Mirage 2005 conference (Paris) [17]
- Tung LE THANH and André Gagalowicz published a paper in the CAIP 2005 conference (Paris) [18]
- Richard Roussel and André Gagalowicz published a paper in the Mirage 2005 conference (Paris) [21]
- Richard Roussel and André Gagalowicz published a paper in the CAIP 2005 conference (Paris) [22]
- Chee Kwang Quah and André Gagalowicz published a paper in the Mirage 2005 conference (Paris) [20]
- Chee Kwang Quah, Richard Roussel and André Gagalowicz published a paper in the CAIP 2005 conference (Paris) [19]
- André Gagalowicz has presented an invited paper at Graphikon 2005 in [16]
- André Gagalowicz has presented an invited paper at VVG 05 in [15]

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