Compte-rendu intermédiaire

Projet ANR-10- CHEX-014-01

Shape Analysis and Registration of People Using Dynamic Data

Programme Chaire d'Excellence 2010

A IDENTIFICATION

Acronyme du projet	SHARED
Titre du projet	Shape Analysis and Registration of People Using Dynamic Data
Coordinateur du projet (société/organisme)	Hyewon SEO (UMR 7005 LSIIT/Université de Strasbourg)
Date de début du projet Date de fin du projet	15.12.2010 14.12.2014
Labels et correspondants des pôles de compétitivité (pôle, nom et courriel du corresp.)	-
Site web du projet, le cas échéant	-

Rédacteur de ce rapport	
Civilité, prénom, nom	Mme. Hyewon SEO, Mr. Frederic CORDIER, Mr. Vasyl MYKHALCHUK, Mr. Guoliang LUO, Mr. Frederic LARUE and Mr. Olivier GENEVAUX
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Date de rédaction	28.09.2012
Période faisant l'objet du rapport d'activité	15.12.2010 ~ 28.09.2012

B LIVRABLES ET JALONS

Initially, we have foreseen the participation of a PhD student in this project from the very beginning of the project. However, due to the late recruitment of PhD candidates (mentioned in our T06 report), every deliverable of the project has been more or less slightly rescheduled by +6 months. This delay concerns Deliverable 1.1 (N°1 in the table), Deliverable 1.2 (N°2), Deliverable 1.3 (N°4), and Milestone #1 (N°3).

On the other hand, two deliverables (N°5 and N°6 in the table) have been newly added, which were not in the initial list. Please refer to sections C.2, C.4 and C.7 for detailed explanations.

N°	Intitulé	Nature*	Date de fourniture			Partenaires (souligner le responsable)
			Prévue initialement	Replanifiée	Livrée	
1	Specification of data acquisition process	Document	M6 Jun. 2011	M15	M15 Mar. 2012	Unistra
2	Dynamic feature extractor solution	Software	M12 Dec 2011	M15	M15 Mar. 2012	Unistra
3	Getting the flow of information between the data acquisition process (T1 of WP1) and the feature extraction of dynamic data (T2 of WP1)	Milestone	M12 Dec 2011	M18	M18 Jun. 2012	Unistra
4	Multiple datasets with their dynamic features extracted	Data files	M13 Jan 2012	M18 Jun. 2012	M18 Jun. 2012	Unistra
5	Segmentation solution	Software	-	M18	M18	Unistra
6	Landmark transfer	Software	-	M18	M18	Unistra

C RAPPORT D'AVANCEMENT

C.1 OBJECTIFS INITIAUX DU PROJET

As clearly stated in our project proposal, the overall objective of SHARED is to develop a shape analysis and novel registration technique that makes use of dynamic properties of deforming surfaces.

In particular, the specific objectives that had been planned during the period of T0—T18 has been the following:

1. Design **shape acquisition and analysis method** where kinematic properties can be fully learned;
2. Develop **new registration techniques** that uses the kinematic properties obtained above so as to put similar deformation behaviors in correspondence;

C.2 TRAVAUX EFFECTUES ET RESULTATS ATTEINTS SUR LA PERIODE CONCERNEE

1. Shape acquisition and analysis method

1.1) Dynamic data acquisition:

Using our multi-view optical motion capture system, we have successfully recorded tracked locations of material points that have been placed on faces exhibiting various expressions. A series of post-processing tools have been developed, so as to transfer the sequence of marker position to 'animation sequence', i.e. mesh sequence with fixed topology. This drastically simplifies further processing, including the feature extraction, segmentation and registration.

1.2) Dynamic feature extraction/segmentation:

- We have devised a numerical method for analyzing the animation sequence by observing the changes in stretching and bending for each graphical entity (vertex or triangle). After the temporal integration of these changes, which we encode in the form of time-varying dynamic descriptor, we identify local maxima with significant deformation behavior and label them as dynamic characteristic points or feature points.

- We have investigated a new method for automatic spatio-temporal segmentation of dynamic mesh, which incorporates two main parts: temporal segmentation and spatial segmentation within each temporal cluster. Segmentations are made in such a say that within-subsequence affinities and within-cluster affinities are maximized.

2. New registration techniques

2.1) Dense correspondence finding:

Development of a new registration technique is under progress, which uses the kinematic properties of the deforming surfaces so as to put similar deformation behaviors in correspondence. We have initially formulated and tried to solve the registration problem as a large optimization problem, trying to find the matching among all points in the dynamic mesh. However, such an approach soon turned out to be impractical, due to the huge dimensionality.

Our solution to speed up the computation time is to first perform consistent spatial segmentation between the source and target meshes, and to carry out registration in a per-segment basis. This will divide the current optimization problem of huge size (approximately 3 times the number of vertices in the mesh) into several number of smaller ones, thus drastically improving the computation time. While working on the segmentation mesh sequences (by the second PhD candidate), we (with the first PhD candidate) have focused on the problem of automatic transfer of landmark points that are supposedly sparsely sampled over the mesh, as described below in 2.2.

2.2) Sparse correspondence finding (landmark transfer):

We have developed an efficient and robust algorithm for the landmark transfer on 3D meshes that are approximately isometric. Given one or more custom landmarks placed by the user on a source mesh, our method efficiently computes corresponding landmarks on a family of target meshes. Differently from existing non-rigid registration techniques, our method detects and uses minimum number of geometric features that are necessary to accurately locate the user-defined feature points and avoids performing unnecessary full registration. Consequently, with minimum user input consistency is assured among landmarks across a set of multiple meshes, regardless of their geometric distinctiveness.

C.3 DIFFICULTES RENCONTREES ET SOLUTIONS

* **Overall delay at the beginning of the project**: Due to the fact that we were unable to recruit PhD candidates at the beginning of the project, the overall schedule had been delayed around 6 months. We have put our efforts to catch up with the initial schedule and as a result, we are likely to be on schedule by June next year.
* **Priority reduction on statistical modeling**: The main research topic planned for the PhD candidate being the inter-subject registration of animation mesh sequence, the statistical atlas reconstruction and the registration based on the atlas has been reserved for the research topic of a post-doc. However, given the competence of the thesis direction team as well as the background of the candidate is more on the geometric modeling rather than statistical analysis, we finally decided 'tempo-spatial segmentation of animation sequence and its application' as the 2nd PhD thesis topic. This implies slight modification of the project plan, especially in the coming 2 years. More specifically, the priority on WP3 (Statistical model construction) and WP4 (Revision of registration with the statistical model) will be reduced, in search of novel geometric techniques such as segmentation and its applications. However, we will try our best to cover the statistical modeling as well and make commitments to sufficiently cover the initial plan.
* **Tight budget constraint:** The project initially planned to engage 1 PhD candidate (3 years) and 1 post-doc (2 years), but we finally decided to recruit 2 PhD candidates (3 years each), seeing that we received several competitive applicants from many nations and that we actually had budget to cover both their salaries. Due to this, our budget has become rather tight, although it is not really crucial.

C.4 FAITS ET RESULTATS MARQUANTS

* **Motion capture data on facial movements**: The facial data we have captured are expensive and rare, as it requires not only high-cost mocap device and experts but also multiple subjects.
* **Automatic estimation of Dynamic Skin Tension Lines in Vivo:** We have developed and published an International journal article on our numerical method for estimating dynamic skin tension lines in-vivo. Defined as the lines of maximal tension, skin tension lines often provide guidelines for surgical incisions because incisions made in the direction of these lines would result in functionally and esthetically pleasing scars. While there exist many comparable lines of static tension, little has been explored on dynamic tension lines. Our method is general enough to be applied to arbitrary postures and individuals, less invasive, and efficient. We demonstrate the dynamic tension lines on various subjects, around the knee and shoulder regions.
* **Landmark transfer**: We have developed an efficient and robust algorithm for the landmark transfer on 3D meshes that are approximately isometric. Given one or more custom landmarks placed by the user on a source mesh, our method efficiently computes corresponding landmarks on a family of target meshes. The technique is useful when a user is interested in characterization and reuse of application-specific landmarks on meshes of similar shape (for instance meshes coming from the same class of objects). Consequently, with minimum user

input consistency is assured among landmarks across a set of multiple meshes, regardless of their geometric distinctiveness.
* **Registration using dynamic data:** In our recent work on registration, we are developing a new registration technique that uses the kinematic properties of the deforming surfaces so as to put similar deformation behaviors in correspondence.
* **Tempo-spatial segmentation of movement data:** We automatically compute temporal and spatial segmentation of the mesh sequence so that the within-segment affinity is maximized. Our technique is one of the first methods dealing with both spatial and temporal segmentation simultaneously.

C.5 TRAVAUX SPECIFIQUES AUX ENTREPRISES (LE CAS ECHEANT)

C.6 REUNIONS DU CONSORTIUM (PROJETS COLLABORATIFS)

All meetings we had with collaborators (Christian Heinrich, Professor at University of Strasbourg, Olivier Genevaux, IR CNRS at University of Strasbourg, Frederic Larue, IR Minister at University of Strasbourg) are listed below. What is not listed are numerous technical meetings (mostly with Frederic Cordier, Assistant professor at University of Haut Alsace) we had with PhD candidates (Vasyl Mykhalchuk and Guoliang Luo), as it would be too exhaustive to list them all. On the average we had 2.5 technical meetings per week, each of them dured around 2 hours.

Date	Lieu	Partenaires présents	Thème de la réunion
16.11.2011	LSIIT, Univ. Strasbourg	Christian Heinrich Vasyl Mykhalchuk Guoliang Luo Hyewon Seo Jean-Michel Dischler	The overview of the project and the possible collaboration with Christian Heinrich in the framework of PhD thesis study of Vasyl Mykhalchuk
28.03.2012	LSIIT, Univ. Strasbourg	Frederic Larue Olivier Genevaux Vasyl Mykhalchuk	Mocap session of 2 persons
29.03.2012	LSIIT, Univ. Strasbourg	Frederic Larue Olivier Genevaux Guoliang Luo	Mocap session of 2 persons
25.06.2012	LSIIT, Univ. Strasbourg	Frederic Larue Olivier Genevaux	Mocap session of 2 persons

C.7 COMMENTAIRES LIBRES

Commentaires du coordinateur

The project initially planned to engage only 1 PhD candidate, but we finally decided to recruit 2nd PhD candidate as well, seeing that we received several competitive applicants from many nations and that we actually had budget to cover their salaries. The main problem we encountered with the 2nd PhD candidate had been to find a good research topic for his thesis study. The main research topic planned for the PhD candidate being the inter-subject registration of animation mesh sequence, the statistical atlas reconstruction and the registration based on the atlas has been reserved for the research topic of a post-doc. However, given the competence of the thesis direction team as well as the background of the candidate is more on the geometric modeling rather than statistical analysis, we finally decided 'tempo-spatial

segmentation of animation sequence and its application' as the 2nd PhD thesis topic. This implies slight modification of the project plan, especially in the coming 2 years. Also, due to the fact that we were unable to recruit PhD candidates at the beginning of the project, the overall schedule has been delayed around 6 months. However, this delay is very likely be caught up with by next year. We have so far published 1 international journal article, and 2 international journal articles are under preparation, which we plan to submit in October. In the coming months, we plan to open a website to make our captured data and results available publicly. Overall, we believe the project is in good shape and making progress that corresponds to the global timetable of the project.

Commentaires des autres partenaires

Question(s) posée(s) à l'ANR

During the thesis supervision of the two PhD students (Guoliang Luo and Vasyl Mykhalchuk), Frederic Cordier (Maitre de Conference, Universite de Haut Alsace) has participated to the project as a co-encadrement since September 2011. Given his considerable contribution to the thesis supervision, I would like to include Frederic Cordier as an official participant of the project. Would ANR agree on this point?

D VALORISATION ET IMPACT DU PROJET DEPUIS LE DEBUT

D.1 PUBLICATIONS ET COMMUNICATIONS

Liste des publications monopartenaires (impliquant un seul partenaire)		
International	Revues à comité de lecture	1. Seo H., Kim S., Cordier F., Choi J. and Hong K., Estimating Dynamic Skin Tension Lines in Vivo using 3D Scans, Computer-Aided Design, (Proc. ACM Symposium on Solid and Physical Modeling 2012, October 29-31, Dijon, France), Elsevier.
	Ouvrages ou chapitres d'ouvrage	
	Communications (conférence)	
France	Revues à comité de lecture	
	Ouvrages ou chapitres d'ouvrage	
	Communications (conférence)	
Actions de diffusion	Articles de vulgarisation	
	Conférences de vulgarisation	
	Autres	

D.2 AUTRES ELEMENTS DE VALORISATION

Liste des éléments. Préciser les titres, années et commentaires	
Brevets internationaux obtenus	1. 2.
Brevet internationaux en	1.

cours d'obtention	2.
Brevets nationaux obtenus	1. 2.
Brevet nationaux en cours d'obtention	1. 2.
Licences d'exploitation (obtention / cession)	1. 2.
Créations d'entreprises ou essaimage	1. 2.
Nouveaux projets collaboratifs	1. 2.
Colloques scientifiques	1. "Registration using Dynamic Data: Data acquisition and analysis of dynamic data", journée Imagerie Robotique Médicale et Chirurgicale (IRMC) de Strasbourg, IRCAD, Hôpitaux Universitaires, Strasbourg, 15 juin 2010. 2. "Human Body Modeling Based on 3D Scans for Cloth Design (en Coreen)", Korea Research Institute of Standards and Science (KRISS), aout 2010. 3. "Measurement and analysis of human skin deformation – Extracting dynamic skin tension lines", Axe Acquisition, Numérisation et Modélisation 3D (ANM3D), Université de Strasbourg, 8 mars 2011. 4. "Human body modeling based on examples", Korea Science and Technology Annual Meeting 2012, Seoul, Corée du Sud, 5 juillet 2012.
Autres (préciser)	1. 2.

D.3 POLES DE COMPETITIVITE (PROJET LABELLISES)

D.4 PERSONNELS RECRUTES EN CDD (HORS STAGIAIRES)

Identification				**Avant le recrutement sur le projet**			**Recrutement sur le projet**			
Nom et prénom	Sexe H/F	Adresse email (1)	Date des dernières nouvelles	Dernier diplôme obtenu au moment du recrutement	Lieu d'études (France, UE, hors UE)	Expérience prof. antérieure (ans)	Partenaire ayant embauché la personne	Poste dans le projet (2)	Date de recrutement	Durée missions (mois) (3)
Luo Guoliang	H	gluo@unistra.fr	Travail en cours	Master	UE (Suede)	0		doctorant	15/09/2011	0
Mykhalchuk Vasyl	H	mykhalchuk@unistra.fr	Travail en cours	Master	Hors UE (Ukraine)	2	Ciklum Ltd (Ukraine), Melior games (Ukraine)	doctorant	15/10/2011	0

D.5 ÉTAT FINANCIER

Nom du partenaire	**Crédits consommés (en %)**	**Commentaire éventuel**
Univ. de Strasbourg	30.63% (67 391.96€ / 220 000€)	

E ANNEXES: MOCAP DATA ACQUISITION PROCESS (DELIVERABLE 1.1)

By means of our motion capture (mocap for short) data acquisition process we aim at supplying researchers with real-world dynamic data sets in a form of animated meshes. This data will be used in the new segmentation, registration, and compression methods, i.e. all related techniques for dynamic mesh processing. At the current stage we focus on a certain part of human body, namely on human face. We are interested in a database of multi-subject dynamic meshes exhibiting intra-subject facial motions (expressions of emotions, lip movements, speaking, etc.), and coherent inter-subject facial motions (i.e. different subjects show exactly the same emotions and spell exactly the same words, etc). Among subjects for data acquisition there's no preference for gender proportion or age distribution. At the moment we have acquired the data from 6 distinct subjects.

The MOCAP system

Our system was custom-assembled of five Vicon T40 and of seven Vicon T40-S cameras. Such cameras are specifically tailored for marker motion capture and have a resolution of 4 megapixels, capture 10-bit gray scale using 2336 x 1728 pixels and can capture speeds of up to 2,000 frames per second. Entire set of twelve cameras is placed in the motion capture zone and forms a semi sphere around a subject (Fig. 1). We configured the system to capture marker positions at 120 frame rate.

(a) (b)

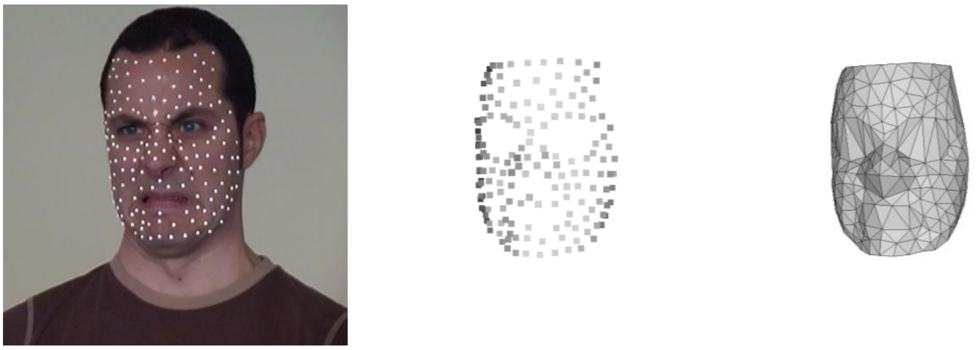
Fig. 1: Vicon system installation (a) 12 cameras positioned in a semi sphere (b) subject of the motion capture is placed just in front of the system.

Data Acquisition

MOCAP session for data acquisition typically consists of the following stages:

- Set up markers
- Capture marker trajectories
- Data post-processing

1. Set up markers. We estimated that for each subject we need from 120 to 200 of light reflective markers for robust data acquisition (may vary from one person to another). Currently we are using a set up with 160 markers (Fig. 2(a)). Entire surface of the face surface should be covered. Markers have to span all over the face till the indicative boundaries defined by the hair, chin lines, etc. Ideally, any nearest 3 markers from the marker set should form a triangle which resembles the local face surface as much as possible; although it is extremely difficult to achieve in practice. We paid a lot of attention to the inter-marker distance: markers should be kept close enough to each other (0.8-1cm apart, depending on a subject and number of markers). Regions of high deformations (for instance, mouth area) should be covered by markers more densely; beside that we tried to place markers as regular as possible.
2. Capture markers trajectories. A person with markers is placed in front of Vicon system; then, the actor performs all the motions (normally motions are predefined and discussed before the session starts). Before the mocap session, the participant shall make some exercises. One should be an actor, performing with exaggerated expressions. The Vicon cameras capture trajectories of the markers individually; the output trajectories data set is stored in one single binary file in .c3d format.
3. Data post-processing. After acquiring raw markers movement data, an engineer needs to post-process the data in order to construct a dynamic mesh. First, the engineer labels the trajectories if needed (during the motion capture some markers may disappear for a frame or two due to occlusions) with Vicon Blade software. Second, our software extracts the coordinates of each marker in every frame. As a result each frame is represented as a point cloud (Fig. 2(b)). Assuming the topology remains the same during the motion capture, we only need to triangulate only first frame for a subject (Fig. 2(c)). Finally, after transferring of the topology information to all point cloud frames we obtain a dynamic mesh sequence.



(a) (b) (c)

Fig. 2: Data aqcuisition in MOCAP session (a) Actor with markers in place. (b) Point cloud acquired for each frame during the MOCAP session. Points represent marker locations. (c) Triangulated point cloud. While keeping the topology consistent over the frames we get a dynamic mesh.