Projet ANR- 10-CHEX-014-01

SHARED: Shape Analysis and Registration of People Using Dynamic Data

Programme Chaire d’Excellence 2010

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# Identification

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| 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 | - |

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| Rédacteur de ce rapport | |
| Civilité, prénom, nom | Mme. Hyewon SEO, Mr. Frederic CORDIER, Mr. Vasyl MYKHALCHUK, Mr. Guoliang LUO, Mr. Frederic LARUE, Mr. Olivier GENEVAUX |
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| Date de rédaction | 15.06.2013 |
| Période faisant l’objet du rapport d’activité | 15.09.2012  ~ 15.06.2013 |

# Livrables et jalons

| **N°** | **Intitulé** | **Nature\*** | **Date de fourniture** | | | **Partenaires** (souligner le responsable) |
| --- | --- | --- | --- | --- | --- | --- |
| Prévue initialement | Replanifiée | Livrée |
| 1 | D2.1 Registration prototype and test results | Logiciel | Dec 2012  (M24) | Sep 2013  (M32) | - | Unistra |
| 2 | D2.2 Research results and publications | Document+ données | Juin 2013  (M30) | - | Juin 2013  (M30) | Unistra |
| 3 | D2.3 Multiple dataset registered | Données | Juin 2013  (M30) | - | Juin 2013  (M30) | Unistra |
| 4 | M2: A population of dynamic data successfully processed by the registration | Jalon | Juin 2013  (M30) | Nov 2013  (M34) | - | Unistra |
| 5 | D2.4 Compression solution of 3D animation sequences | Logiciel+ document | - | Mai 2013  (M29) | Mai 2013  (M29) | Unistra |

# Rapport d’avancement

## Objectifs initiaux du projet

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| 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 entities**. In particular, the specific objectives that had been planned during the period of T19—T30 have been the following:  1. Development of new **surface registration techniques** that makes use of the time-varying features encoding the deformation behavior of the graphical entities. With the formulation of an optimization problem, we aim at finding spatio-temporal correspondence that minimizes the dissimilarity (error) in surface distance, deformation gradient tensor, etc.  2. Development of **tempo-spatial segmentation** of deforming mesh sequence that automatically computes the temporal and spatial segmentation of the given mesh sequence, so as to maximize the within- segment affinities. We aim at further extending the work towards similarity measure on movement data, (dynamic) shape query, and compression of mesh sequence.  3. Statistical model construction: We mention this objective here just to remind ourselves with the very initial plan of the project, as it has been slightly modified last year when we have decided to reduce the priority on it (Please refer to our previous intermediate report (T18)). We compensate this by putting more priority on the objective 2, which has been newly set last year. |

## Travaux effectués et résultats atteints sur la période concernée

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| **Registration of surface data - Static case [1].** We have modified our previously developed landmark transfer algorithm and applied it to a dense correspondence problem, mainly for validation/comparison purpose. The core idea of the landmark transfer, which essentially is a sparse correspondence computation using modified geodesic distances to geometric features, has been extended to a more general problem of the dense correspondence by considering every vertex on a source mesh as a landmark. We validated the results of the method by comparing it to the state-of-the-art shape matching methods: Mobius Voting and Blended Intrinsic Maps (BIM). The benchmark data included full Tosca dataset from the [Tosca shape repository](http://tosca.cs.technion.ac.il/book/resources_data.html), which is composed of more than 80 meshes. We have measured geodesic errors with respect to the ground-truth for each of the methods, and have shown that our method performs far better than Mobius Voting, and slightly better than to BIM in terms of maximum error values.  **Registration of surface data - Dynamic case.** A new method for a pair-wise registration of deforming mesh sequences is currently in progress. Two slightly different problems have been formulated: A “spatial” registration problem where we find a temporal correspondence followed by a spatial one that maximizes motion similarity and other matching qualities, and a “spatio-temporal” one where we find correspondence in the space-time embedding. In the context of spatial registration, we have extracted dynamic feature points by using triangle strain as a characteristic of surface motion. Extreme points of the average or maximum principal strain values in local surface neighbourhoods have been taken as features. However, unlike our expectation, the results have not shown sufficient level of inter-subject consistency. We plan to improve the consistency among extracted features by replacing strains with time-varying strain tensor fields. We then will focus on the implementation of developed ideas on the registration.  **Temporal segmentation of deforming mesh [2].** We have devised a new method for analysing a deforming mesh by using the deformation behaviour (stretch and bending) of each mesh triangle. After measuring the distances of triangle deformation between each frame pair, temporal segmentation is performed by finding frame boundaries that minimize within-segment distances. Our experimentation on numerous examples has shown that we can obtain consistent temporal segmentation on different deforming meshes exhibiting identical or similar motions, despite their shape differences.  **Compression of deforming mesh [3].** We have developed a compression method for 3D mesh sequences. We first aggregate similar frames into frame clusters, then apply principal component analysis for each cluster, and finally perform intra-cluster compression based on linear coding. Because the frame poses within a cluster are similar, the number of principal coefficients required for each cluster is reduced, leading to a better compression ratio for a given reconstruction error than other comparable methods.  **Similarities between two deforming meshes.** We have investigated a new method for measuring motion similarity between two deforming meshes, independently from their shape similarities at static frames. Our method proceeds as follows: (1) We first compute an initial spatio-temporal segmentation by clustering the triangles that undergo similar deformation and are either temporally or spatially connected. (2) We then compute an initial spatial segmentation by cutting the mesh along the boundaries of each spatio-temporal segment. (3) We introduce a spatio-temporal cluster graph that efficiently represents the segmentation results. (4) Finally, we define a similarity measure between two spatio-temporal cluster graphs, so as to measure the similarity of motions they encode. Our experiments on a few deforming meshes show that our method can be used to identify similarities and distinguish differences in motions, independently from shape differences. In the next stage, we plan to further validate our work by populating our dataset, and by acquiring ground truth data.  [1] Mykhalchuk V., Cordier F., Seo H.: Landmark Transfer with Minimal Graph. Computers & Graphics (Elsevier), Vol. 37, Issue 5, pp. 539–552, 2013.  [2] Luo G., Seo H., Cordier F.: Temporal segmentation of deforming mesh. Pacific Graphics Short Papers, The Eurographics Association, 2013. (under review)  [3] Luo G., Cordier F., Seo H.: Compression of 3D mesh sequences by temporal segmentation. Computer Animation and Virtual Worlds, Vol. 24, pp. 365–375, 2013. |

## Difficultés rencontrées et solutions

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| **The lack of dynamic data.** We have found that we are in great need of a rich set of dynamic, time-varying geometry data. For the moment we are working with a limited set of deforming meshes coming from various sources: Mesh sequences from Deformation Transfer by [Sumner et al.](http://people.csail.mit.edu/sumner/research/deftransfer/data.html), a set of synthetic facial animations originated from [KAIST](http://vml.kaist.ac.kr/), a few number of deforming meshes we have created by rigging some of the anthropoid models from [Tosca shape repository](http://tosca.cs.technion.ac.il/book/resources_data.html). However, the quantity and quality of these datasets are not fully satisfactory for our needs. Thus we have tried to engage a 3D modeller in our research group, who has started working on different animal models with the same motion. We also found that the mocap data we have obtained during last year are not quite usable as such, as their spatial resolution is rather low. Therefore, we plan to acquire face surface scans of multiple individuals and automatically drive their deformations by transferring the captured animation of mocap data.  **Acquisition of ground truth data**. It is of high importance to produce ground truth registration/segmentation data in order to validate our methods. However it typically involves manual correspondence marking, which is not only tedious but also extremely difficult in case of animated mesh sequences. For the validation of the registration method, we will find examples where static registration methods fail, and will show that our registration is able to find correspondence well by using the motion information. For the validation of our segmentation work, we will ask volunteers to manually rate the similarity among dataset.We can then compare the similarity ratings from ground truth and those computed by using our method. This will allow us to avoid having to work on ground-truth segmentations, while being able to validate the work effectively. |

## Faits et résultats marquants

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| As an outcome of our work we have delivered several algorithms and publications.  **Sparse and dense registration of static shapes**. We have developed an efficient and robust algorithm for the landmark transfer on 3D meshes that are approximately isometric. The main advantage of our method over existing approaches is its low computation time. Differently from existing non-rigid registration techniques, our method detects and uses a minimum number of geometric features that are necessary to accurately locate the user-defined landmarks and avoids performing unnecessary full registration. In addition, our method can handle the deviation of isometric deformation order to handle the deviation of isometric deformation by adopting histograms of geodesic distance and inverse distance weighting to interpolate intrinsic distances on the source and the target. While we have developed the method for the sparse correspondence problem, it is applicable to the dense cases as well. The work has been accepted for publication in Computers & Graphics journal, along with the source code and executable provided by the publisher, at [Collage Authoring Environment](https://collage.elsevier.com/collage/multimaster?doi=10.1016/j.cag.2013.04.005&timestamp=20130613054637&digest=0d64dfacba54865446894e2a90442bae).  **Spatio-temporal segmentation of deforming mesh.** To the best of our knowledge, no previous work has been made on the spatio-temporal segmentation of deforming meshes. Encouragingly, our experimentation on a number of examples confirms the effectiveness of the presented approach. More importantly, it shows that we can obtain consistent temporal segmentations on different deforming meshes exhibiting identical or similar motions, despite their shape differences.  **Compression of 3D mesh sequences by temporal segmentation.** We have developed a compression method for three-dimensional animation sequences that has notable advantages over existing techniques. The key to efficient compression is the aggregation of similar poses into frame clusters, which allows us to reduce the number of principal coefficients required for each frame. Results show that our method can obtain a higher compression ratio for a given reconstruction error than other comparable methods. |

## Travaux spécifiques aux entreprises (le cas échéant)

## Réunions du consortium (projets collaboratifs)

| **Date** | **Lieu** | **Partenaires présents** | **Thème de la réunion** |
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## Commentaires libres

Commentaires du coordinateur

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| \* General remarks: During the period of 2012-2013, we have published 3 international journal articles (Computer Aided Design, Computers & Graphics, Computer Animation and Virtual Worlds) and have submitted 1 international conference paper (Pacific Graphics). In 2013, we plan to submit at least 1 more article to an international conference (with journal publication). Overall, we believe that we are in good shape and have made progress according to the plan that we set last year, although we are approximately 6 months behind the schedule that have been initially set. In the coming year, we plan to complete our works on tempo-spatial segmentation and surface (or 4-D) registration using dynamic data, with rigorous validation and quality publications.  \* Detail remarks:  The newly added task, tempo-spatial segmentation on mesh sequence, has been a challenging one for us for two reasons: (1) We are the first people working on this subject although there exist a large body of comparable/profitable works in video processing, and (2) the subject is relatively new to the team. Thanks to our immense efforts, however, we start to have some promising results. We plan to further develop our current method and make rigorous experiments in the coming year. In particular, we will focus on the graph-based encoding, and similarity measure of, mesh sequences, which we will demonstrate by measuring motion-similarities on a large number of dynamic dataset. However, such dataset does not exist today, and acquiring it seems a big challenge. The data we are currently using come from various sources (some publically available dataset from previous works on deformation transfer [1] and facial expression cloning [2], some are made by our own, and others we acquired from the motion capture), but are very limited in quantity. Also, the data from motion capture is not fully satisfactory as its spatial sampling is rather sparse. To take up this challenge, we (with stagier students) started to develop methods that combine motion-capture data and mesh data from scan imaging, allowing densely sampled data both temporally and spatially.  The development of the new registration technique on dynamic datahas been through several pause-and-resume phases due to the revision of a journal article. The reviewers of the journal have requested us to rigorously validate our landmark transfer work on large benchmark data, comparing it with several state-of-the-art works. This has required us to process a large dataset, to communicate with authors of other papers, and sometimes to implement existing methods. In the end, these turned out to be very useful for the completeness of our work, but we somehow spent some considerable amount of time, which was not part of the initial/recent plan. We plan to fully concentrate on this task in the coming year.  We have opened a project website (<http://shared.u-strasbg.fr>), where we make our motion captured data available. We plan to enrich this website with mesh sequences we have generated/tested in our experiments. Thanks to our collaboration with others inside and outside our research team, we are very likely to realize this plan.  Lastly but not least, the principal members of the project team (Hyewon SEO, project responsible, Vasyl MYKHALCHUK, PhD candidate and Guoliang LUO, PhD candidate) plan to commit a 1-month mission at the MIRALab, University of Geneva (invited by Prof. Nadia Magnenat-Thalmann). It is our wish to make this mission fruitful for everyone involved. In particular, it will open a unique opportunity to extend/disseminate our work to medical data, as we will collaborate with MIRALab members who work on a medical project (MultiscaleHuman, EU FP7-PEOPLE). We also expect to establish a long-term scientific collaboration, reinforce our research network, and to nourish the careers of PhD candidates.  [1] Sumner R. W., Popovic J.: Deformation Transfer for Triangle Meshes. ACM Transactions on Graphics, 23(3), 2004.  [2] Noh J. Y., Neumann U.: Facial Expression Cloning. ACM SIGGRAPH 2001, pp. 277-288, 2001. |

Commentaires des autres partenaires

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Question(s) posée(s) à l’ANR

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| As we had difficulties recruiting PhD candidates with the commence of the project, the overall schedule had been delayed around 6 months. Despite all our efforts to catch up with the initial schedule, we are afraid that the delay of the project is unavoidable. Thus, we would like to ask the authorization of ANR on the prolongation of the project duration till June 2015. |

# Valorisation et impact du projet depuis le début

## Publications et communications

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| **Liste des publications multipartenaires (résultant d’un travail mené en commun)** | | |
| **International** | **Revues à comité de lecture** |  |
| **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** |  |

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| **Liste des publications monopartenaires (impliquant un seul partenaire)** | | |
| **International** | **Revues à comité de lecture** | 1. Mykhalchuk V., Cordier F., Seo H.: Landmark Transfer with Minimal Graph. Computers & Graphics (Elsevier), Vol. 37, Issue 5, pp. 539-552, 2013. 2. 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. 3. Luo G., Cordier F., Seo, H.: Compression of 3D mesh sequences by temporal segmentation. Computer Animation and Virtual Worlds, (CASA’13), Vol. 24, pp. 365–375, 2013. |
| **Ouvrages ou chapitres d’ouvrage** |  |
| **Communications (conférence)** | 1. Luo G., Seo H., Cordier F.: Temporal segmentation of deforming mesh. Pacific Graphics Short Papers, The Eurographics Association, 2013. (under review) 2. Luo G., Cordier F., Seo, H.: Compression of 3D mesh sequences by temporal segmentation. Proc. 26th Int'l conference on Computer Animation and Social Agents 2013, May 16-18, Istanbul, Turkey. 3. Seo H., Kim S., Cordier F., Choi J. and Hong K.: Estimating Dynamic Skin Tension Lines in Vivo using 3D Scans, ACM Symposium on Solid and Physical Modeling 2012, October 29-31, Dijon, France. |
| **France** | **Revues à comité de lecture** |  |
| **Ouvrages ou chapitres d’ouvrage** |  |
| **Communications (conférence)** |  |
| **Actions de diffusion** | **Articles de vulgarisation** |  |
| **Conférences de vulgarisation** |  |
| **Autres** |  |

## Autres éléments de valorisation

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| **Liste des éléments. Préciser les titres, années et commentaires** | |
| **Brevets internationaux obtenus** |  |
| **Brevet internationaux en cours d’obtention** |  |
| **Brevets nationaux obtenus** |  |
| **Brevet nationaux en cours d’obtention** |  |
| **Licences d’exploitation (obtention / cession)** |  |
| **Créations d’entreprises ou essaimage** |  |
| **Nouveaux projets collaboratifs** |  |
| **Colloques scientifiques** | 1. Hyewon SEO, "Landmark transfer with minimal graph", visiting lab seminar, GeoMod, LIRIS, University of Lyon, July 2013. 2. Hyewon SEO, "Shape analysis and registration of people using dynamic data", presentation at team meeting, IGG, ICube, June 2013. 3. Guoliang LUO, "Spatio-temporal segmentation of mesh sequence", presentation at comité de suivi, IGG, Icube, June 2013. 4. Vasyl MYKHALCHUK, "Surface registration : static and dynamic cases", presentation at comité de suivi, IGG, Icube, June 2013. 5. Frederic Cordier, "Compression of 3D mesh sequences by temporal segmentation", presentation at CASA’13, Istanbul, Turkey, May 2013. 6. Hyewon SEO, "Shape analysis and registration of people using dynamic data", visiting lab seminar, MIRALab, Université de Genève, Suisse, January 2013. 7. Guoliang LUO, "Tempo-spatial segmentation of mesh sequence", presentation at internal seminar, IGG, ICube, December 2012. 8. Vasyl Mykhalchuk, "Landmark transfer with minimal graph", presentation at internal seminar, IGG, ICube, November 2012. |
| **Autres (préciser)** |  |

## Pôles de compétitivité (projet labellisés)

## Personnels recrutés en CDD (hors stagiaires)

## État financier

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| --- | --- | --- |
| **Nom du partenaire** | **Crédits**  **consommés**  **(en %)** | **Commentaire éventuel** |
| Université de Strasbourg | 44.29 % (97,451.72 € / 220 000 €) | Status on 20/03/2013 |
| Université de Strasbourg | 51.47 % (113,232.14 € / 220 000 €) | Status on 01/06/2013 |

# Annexes