| | | | |
|---|---|---|---|
| **Acronyme / Acronym** | **CrABEx** | | |
| **Titre du projet** | Création de contenu graphique 3D Assistée par une Base d'Exemples | | |
| **Proposal title** | Example-based 3D-modelling Support | | |
| **Axe(s) thématique(s) / theme(s)** | ☑ 1 ☑ 2 ☐ 3 ☐ 4 ☐ 5 | | |
| **Type de recherche / Type of research** | ☑ Recherche Fondamentale / Basic Research<br>☐ Recherche Industrielle / Industrial Research<br>☐ Développement Expérimental / Experimental Development | | |
| **Coopération internationale (si applicable) / International cooperation (if applicable)** | ☑ Non ☐ Oui | | |
| **Aide totale demandée / Grant requested** | **484 123,05 €** (hors frais de gestion et frais généraux) | **Durée du projet / Projet duration** | 48 mois |
| **Partenaire coordinateur / Coordinator partner** | **Jean-Philippe Vandeborre**<br>**jean-philippe.vandeborre@lifl.fr**<br>Maître de Conférences HDR de l'Institut Mines-Telecom<br>LIFL (Laboratoire d'Informatique Fondamentale de Lille)<br>UMR 8022 Lille1/CNRS – Université Lille 1 | | |
| **Lien avec un projet du programme *Investissements d'Avenir (IA) / Link with a project of the Investement for the Future program*** | ☑ Non ☐ Oui | | |

## Personnes impliquées dans le projet / People involved in the project :

| Etablissement / Organization | Nom / Name | Prénom / First name | Emploi actuel / Current position | Implication dans le projet en pers.mois / Involvement in the project (PM) | Rôle & Responsabilité dans le projet / Contribution to the project |
|---|---|---|---|---|---|
| Université Lille1<br>LIFL UMR 8022 Lille1/CNRS | VANDEBORRE | Jean-Philippe | Maître de Conférences (HDR) | 30 | **Coordinateur du projet et responsable scientifique et technique (partenaire n°1)**<br>Expert en indexation, segmentation et analyse de maillages 3D |
| Université Lille1<br>LIFL UMR 8022 Lille1/CNRS | WANNOUS | Hazem | Maître de Conférences | 18 | Expert en analyse textures, couleurs et mouvements |
| Université Claude Bernard Lyon 1<br>LIRIS UMR 5205 | LAVOUÉ | Guillaume | Maître de Conférences | 20 | **Responsable scientifique et technique (partenaire n°2)**<br>Expert en segmentation, indexation de maillages 3D et perception/expérimentation subjective |
| Université Claude Bernard Lyon 1<br>LIRIS UMR 5205 | DUPONT | Florent | Professeur | 15 | Expert en compression et analyse de maillages 3D |
| Université Claude Bernard Lyon 1<br>LIRIS UMR 5205 | DENIS | Florence | Maître de Conférences | 15 | Experte en reconstruction, compression, tatouage, analyse de maillages 3D |
| Université Claude Bernard Lyon 1<br>LIRIS UMR 5205 | VIDAL | Vincent | Maître de Conférences | 12 | Expert en segmentation et analyse de maillages 3D, et en remaillage |
| Télécom ParisTech<br>LTCI UMR 5141 | TIERNY | Julien | Chargé de Recherches | 20 | **Responsable scientifique et technique (partenaire n°3)**<br>Expert en analyse géométrique et topologique (dont *cross-parametrization*) |
| Université Lumière Lyon 2<br>ICOM / Gamagora | GESQUIÈRE | Gilles | Professeur | 12 | **Responsable scientifique et technique (partenaire n°4)**<br>Expert en modélisation géométrique |
| Université Lumière Lyon 2<br>ICOM / Gamagora | GALIN | Eric | Professeur | 12 | Expert en génération procédurale 3D et production pour le jeu vidéo |
| 3DDUO | DEVOGHELAERE | Maxence | CEO | 6 | **Responsable scientifique et technique (partenaire n°5)** |
| 3DDUO | HOWENYING | Mario | Lead 3D modeler | 12 | Expert en modélisation 3D pour le jeu vidéo et le *serious game* |
| 3DDUO | BERG | Arnaud | R&D Director | 12 | Ingénieur informaticien, développement jeux vidéo et plateforme |

# 1. RESUME DE LA PROPOSITION DE PROJET / EXECUTIVE SUMMARY OF THE PROPOSAL

**Résumé en français :**

Le projet CrABEx concerne la chaine de production et d'édition du contenu 3D, dans le cadre des applications de type loisir numérique (film d'animation, jeux vidéo, *serious games*). Les avancées dans les domaines du jeu, de l'animation, de la modélisation physique ainsi que dans les techniques de capture et d'affichage 3D entrainent une production accrue des ressources graphiques 3D (avatars, personnages 3D, éléments de décors naturels et architecturaux) ainsi qu'un niveau de qualité de plus en plus élevé. La production de ces ressources graphiques devient un élément majeur dans la chaine de production globale d'un produit de loisir numérique.

L'enjeu du projet est d'apporter une aide dans la création et/ou l'édition de ces ressources graphiques, par l'utilisation d'une base de données de ressources existantes ou créées antérieurement. L'objectif du système visé est d'aider le designer de plusieurs manières possibles : (1) par la suggestion d'éléments appropriés pendant la création/l'édition d'un nouvel objet ; (2) par la génération automatique de nouveaux objets à partir de combinaisons de parties d'objets de la base d'exemples.

Le système visé sera capable de suggérer/produire non seulement des éléments géométriques mais également des méta-données géométriques associées telles que squelettes d'animation, textures, cage de déformation, labellisation sémantique, etc.

Le système reposera sur deux aspects techniques forts :

- Une approche rapide et efficace d'indexation et d'extraction de contenu 3D.
- Des algorithmes de mise en correspondance pour l'assemblage cohérent d'éléments 3D issus de plusieurs sources ainsi que pour l'ajustement de leurs méta-données géométriques associées.

Enfin, les résultats scientifiques de ce projet seront intégrés dans les outils utilisés par deux partenaires du projet : par une extension pour le logiciel 3D *Maya*, utilisé dans la formation Gamagora (et par d'autres formations du domaine) ; ainsi que dans la plateforme de création de jeux *Casual Crossing Engine* développée par l'entreprise 3DDUO.

**English summary:**

The CrABEx project deals with the optimization of the production and editing chain of 3D content, in the context of digital entertainment (motion pictures, video games, serious games). Recent advances in the areas of video games, animation, physical modeling as well as in the field of 3D display and acquisition techniques lead to a significant increase of the production of 3D content (avatars, 3D characters, architectural models, etc.). The production of this massive amount of 3D content becomes a major concern for the global production chain in the design of digital entertainment products.

The challenge addressed by this project is to facilitate the creation and editing of this 3D content, with the help of a database of existing 3D models. The target of the envisioned system is to ease designers' task in the following ways: (1) With the on-line suggestion of appropriate parts during the creation/editing of a model;

and (2) with the automatic generation of new content by combination of parts coming from examples of the database.

The envisioned system will be able to suggest/create not only geometrical pieces but also their associated geometric meta-data (animation skeletons, textures, deformation cages, semantic labeling, etc.). The system will rely on two important technical aspects:

- A fast and efficient approach for 3D content indexing and retrieval;
- A fast and efficient approach for the point-to-point registration of models (for the coherent assembly of existing geometry and meta-data onto the input);

Finally, the scientific results of the project will be integrated in the software used by two partners of the project: with a plugin for *Maya*, used by the computer video game school Gamagora (as well as in other school in the same field); and inside the video game design platform *Casual Crossing Engine* developed by the company 3DDUO.

*Note. Afin d'en faciliter la lecture, les sections 2.1, 2.4, 2.6 ainsi que la section 6 (financière) sont rédigées en français. Le reste du document scientifique est rédigé en anglais.*

# 2. CONTEXTE, POSITIONNEMENT ET OBJECTIFS DE LA PROPOSITION / CONTEXT, POSITION AND OBJECTIVES OF THE PROPOSAL

## 2.1. CONTEXTE ET ENJEUX ECONOMIQUES ET SOCIETAUX / CONTEXT, SOCIAL AND ECONOMIC ISSUES

Les développements technologiques récents concernant l'imagerie tridimensionnelle font de la 3D un élément indispensable à toutes les créations multimédias actuelles et futures (cinéma, jeux vidéo, simulation, etc.). Mais ces développements rapides font que le travail des créateurs de mondes virtuels est de plus en plus exigeant, aussi bien en terme de qualité, de quantité, et bien sûr de temps passé à créer les modèles tridimensionnels, éléments de base de ces mondes virtuels. Dans le même temps, les collections de données 3D se sont accumulées et enrichies. Qu'elles soient mises à disposition du public (gratuitement ou non) ou totalement privées (propriétés exclusives des studios de création par exemple), elles regorgent d'éléments réutilisables et pourtant très souvent inexploités.

Comme nous l'avons déjà souligné, l'objectif principal du projet proposé dans ce dossier est **d'optimiser le processus de création qui est l'activité centrale des studios de production et par conséquent l'activité la plus coûteuse.**

L'implication du partenaire 3DDUO, *web-game agency* spécialisée dans le *serious game*, montre bien l'enjeu majeur qu'est, d'une part, l'aide à la création de nouveaux contenus à partir de contenus existants, et d'autre part, l'optimisation et le gain de temps dans le processus de création obtenus par cette aide. L'aspect innovant du projet présenté dans ce dossier a également éveillé l'intérêt des centres de formation des futurs créateurs dans ce domaine en constante évolution. Gamagora, formation spécialisée dans le monde des jeux vidéo au sein de l'Université Lumière Lyon 2, est l'un des partenaires de ce projet. Cette formation tient particulièrement à entretenir et développer ses liens avec la recherche sur des outils qui seront très certainement la base des futurs logiciels utilisés par ses étudiants dans quelques années au sein des formations et des entreprises dans lesquelles ils seront employés.

3DDUO et Gamagora sont des partenaires clefs de ce projet; en premier lieu, dès le début du projet, ils fourniront les données qui nous permettront de créer rapidement une base de grande envergure pour effectuer les tests de la plateforme et des algorithmes que nous développerons dans le cadre de ce projet. Puis, en milieu et fin de projet, ces partenaires participeront activement aux phases d'expérimentation et d'intégration des plateformes intermédiaire et finale. De l'autre côté, les partenaires académiques encadreront et feront participer les étudiants volontaires de Gamagora à ce projet de recherche innovant.

Pour conclure d'un point de vue économique, l'objectif de la plateforme visée par ce projet est la **réduction des coûts et des délais de production** dans les entreprises du loisir numérique et du *serious game*; l'enjeu économique est de taille. En effet, en cinq ans, le marché mondial du logiciel de jeu vidéo passera de 41,9 milliards d'euros en 2011 à presque 60,6 milliards en 2015 (source : http://www.snjv.org/fr/industrie-francaise-jeu-video/). Quant au secteur du *serious game*, il est en pleine expansion, un chiffre d'affaires mondial de 10 milliards d'euros est prévu en 2015. L'enjeu du projet est également dans l'évolution des pratiques; en effet un tel système de création assistée devrait permettre de **définir de nouveaux schémas de collaboration entre designers** et de **démocratiser la création graphique** en la rendant accessible aux utilisateurs novices; enfin cette plateforme pourrait même être utilisé comme une **plateforme pédagogique dans l'enseignement de la création numérique** (dans le cadre d'une formation telle que Gamagora).

## 2.2. OBJECTIFS ET CARACTERE AMBITIEUX ET NOVATEUR DU PROJET / OBJECTIVES, ORIGINALITY AND NOVELTY OF THE PROJECT

With the significant recent developments of 3D displays and web-based 3D technologies, the entertainment industry related to computer graphics (gaming, motion pictures, etc.) has to deal with an important increase of activity. However, the most resource-consuming task in this field is not the production of the software generating virtual worlds, but the production of the 3D data populating these virtual worlds. In order to ease the designers' work and to speed up the production of these 3D models, we propose to develop new approaches for "example-based 3D modeling support", i.e. techniques that enable to re-cycle previous similar designs stored in production databases in order to rapidly create new and original 3D models. The figure on the last page of the document (fig. 6) illustrates our objective and the scientific challenges. These techniques will be integrated in the tools used daily by the computer video game school Gamagora, and the company 3DDUO, both partners in the project.

### 2.2.1 MAIN GOALS

With this project, we envision example-based 3D modeling support in a broad sense. We propose to investigate not only the synthesis of new geometries based on existing examples, but also the synthesis of the *geometric meta-data* that accompany the geometry and that enable its exploitation. Specifically, we aim at designing new approaches for:

- On-the-fly suggestions of geometry completion based on similar existing examples,
- Automatic (and editable) fitting of the geometry completions on the designed input
- Suggestions of accompanying *geometric meta-data* based on existing examples of similar geometry: Texture atlas; Mesh structure (quadrangulations); Bump maps; Volumetric textures; Animation skeletons and skinning weights; Deformation cages
- Automatic (and editable) fitting of the suggested geometric meta-data on the designed input.

### 2.2.2 SCIENTIFIC CHALLENGES

This project covers two main research areas, for which several contributions need to be made:

a) Partial shape retrieval: In order to search the production database for visually similar 3D models, shape retrieval techniques need to be considered.

**Required contributions:** Only few partial shape retrieval techniques (where retrieved shapes should be partially similar to the input) have been proposed. Moreover, existing techniques did not specifically focus on response times so far. **A key ingredient of our project is a partial shape retrieval system which would provide suggestions at interactive speed** (within seconds). To this end, we will focus our research on **progressive partial shape similarity evaluation algorithms**, allowing for a continuous refinement of the similarity-based sorting of the production database. In practice, such a system would provide quickly an initial suggestion list of similar 3D models that would be updated in the background as the similarity estimation gets refined.

Among existing shape retrieval algorithms, very few of them are able to integrate other attributes than the pure geometry in the recognition process. To fully take advantage of the full information of the models we have to consider the meta-data in our algorithms (i.e. texture, skeletons, cages, etc.). This could be another relevant way to facilitate and thus speed-up the process.

b) Cross parameterization: Once relevant and visually similar examples have been selected after the shape retrieval process, their geometric meta-data need to be adapted to the input to enrich its geometry with textures, animation skeletons and so on. We propose to tackle this problem with automatic cross parameterization.

   **Required contributions:** Regarding surface type meta-data (texture atlas, bump maps, mesh structure), surface cross mapping algorithms need be considered. Several automatic techniques have been proposed but they are too time-consuming to be used in an interactive context. Moreover, existing techniques aim at minimizing the introduced distortion globally. This can be detrimental for detail preservation after cross mapping (where low distortion must be guaranteed locally in critical locations and more important distortion can be tolerated in other regions). **Thus, we need to develop new fast algorithms for the automatic surface cross-parameterization with distortion guidance.** For instance, in case of image textures, a distortion guidance field can be computed on the source surface automatically from the analysis of the content of the image texture (to guarantee low distortion on the eyes or the mouth of a character face for example).

   Regarding volumetric meta-data (animation skeleton, deformation cages, volumetric textures), volumetric cross mapping needs to be considered to deform the ambient space embedding the meta-data to make it fit the input. To our knowledge, only volumetric parameterization (mapping a volume to a reference primitive volume like a poly-cube) has been treated in the state-of-the-art, but no algorithm for arbitrary volume cross mapping has been proposed. **Thus, we need to develop new fast algorithms for the automatic volume cross-parameterization** (possibly with distortion guidance).

### 2.2.3 EXPECTED RESULTS AND IMPACTS

With this example-based 3D modeling paradigm, artists would be able to design new and original production-ready 3D models with a minimum amount of interaction. Moreover, as the production database's size increases, more and more relevant suggestions will be proposed to the user. Finally, such a production model enables to easily share experienced designers' expertise to the entire design crew, by the ability to easily mimic the reference models made by the expert designers.

In term of evaluation, we foresee several scientific contributions to the core research areas involved in example-based 3D modeling (partial shape retrieval, cross parameterization). Individually, each of these core contributions will be evaluated with *low-level* performance measurements (for instance, computation timings, recall/precision curves, distortion measurements, etc.); in particular **we plan to participate to the Shape Retrieval Contest SHREC** (e.g. 2015 and 2016 editions). Globally, the relevance of our framework would be evaluated with *high-level* performance measurements, involving the subjective evaluation of human users. This high-level evaluation would imply feedback scoring (to measure the relevance of the suggestions) as well as user studies (to measure the evolution of the users' productivity when using the framework). For this high-level evaluation **we will rely on the computer video game school Gamagora which is one of the partners of the project**. The school will provide students for extensive subjective tests of the platform. **A plugin for the 3D design software *Maya*, used by Gamagora, will also be developed.**

Finally, 3DDUO has developed its own game design platform named *Casual Crossing Engine*. All the actors in the creation of a game at 3DDUO are using this platform: scenario writers, game designers, programmers, 3D designers, etc. **The results of the CrABEx project will be integrated in this platform for usability demonstration and test purposes.**

## 2.3. ÉTAT DE L'ART / STATE OF THE ART

Following a pioneer work by Funkhouser et al. [FKS04], several techniques have been proposed recently for 3D modeling support based on example reuse [CK10, TSS1, CKG11]. However, with this project, we would like to investigate a broader notion of example-based 3D modeling support, where not only the geometry would be synthesized with the help of a corpus of examples, but also all the geometrical meta-data associated with the geometry (textures, animation skeletons, deformation cages, etc.).

Example based 3D modeling support involves multiple core research areas, including shape retrieval and cross parameterization (for meta-data fitting). In the following, we briefly review the state-of-the-art in terms of example-based 3D modeling support. Then, we will focus on specific reviews about shape retrieval and cross parameterization.

### 2.3.1 EXAMPLE BASED 3D MODELING SUPPORT

Funkhouser et al. [FS04] introduced the first example based 3D modeling support technique. By combining shape retrieval and semi-automatic segmentation of the models of a database, the presented system proposes the user to *switch* parts of an input object with those of similar objects found in the database. Recently, Chaudhuri et al. [CK10] presented an enhanced version of this framework enabling suggestions for *additional* pieces of geometry to add onto the input. Unlike the retrieval system used by Funkshouser et al., the search engine here retrieves models based on *partial* similarity with the current status of the input and suggests as additional pieces of geometry the parts of the retrieved models which have not been match during similarity estimation (therefore interpreted as additional pieces).

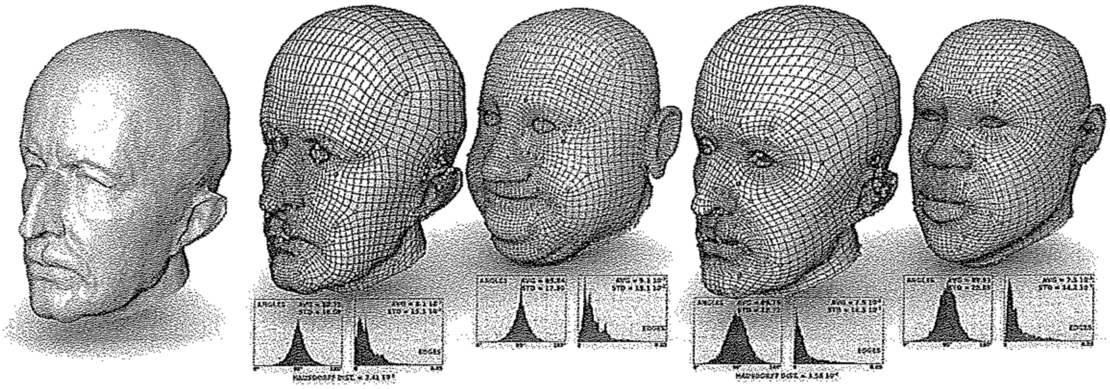

**Figure 1: Inspired Quadrangulations (blue) of an input geometry (gray) based on similar examples (in green) [TDN11]. By introducing a fast as-isometric-as-possible cross mapping algorithm, Tierny et al. present a technique which enables a novice user to easily reproduce the meshing styles found in production databases (see the extraordinary vertex layout).**

Lee et al. [LZC11] propose a user-guidance system for freehand drawing, based on a database of images and a fast indexing mechanism; as the user draws, the system suggests in real time new object contours that could complete the current drawing. The proposed project can be seen as the *translation* of this 2D system for 3D graphics creation.

Chaudhuri et al. [CKG11] propose an assembly-based modeling tool allowing the fast construction of new graphical objects by combining different components from objects of a database. The key of the system lies in the identification of the relevant parts to present to the user regarding the current 3D model that he is creating. This system can be seen as one of the building block of the proposed project; actually it just makes relevant suggestions but requires the user to manually put the components at the right pose and location on the created object. Moreover the indexing relies on very simple descriptors and there is no *smart adaptation* of the existing content to the new one.

To overcome the aforementioned interaction issues, Takayama et al. [TSS11] presented an approach for geometric detail cloning based on interactive cross parameterization. The technique allows for easier interactions based on surface painting, where the user paints on the source model the details to copy and on the target their position for automatic compositing. However, due to inevitable distortion, only relatively small details can be copied and paste reliably (large features might be distorted).

Recently, some partners of the project presented the first technique for example based 3D modeling support not directly related to the geometrical design task but related to *geometric meta-data* design, in particular to surface quadrangulation design [TDN11]. In this work, Tierny et al. proposed the first example based surface quadrangulation technique. Surface quadrangulation is an important aspect of the modeling pipeline and the layout of the meshes is often application dependent or even subjective (depending on the designer's style). To reproduce meshing styles on new input shapes, the presented technique relied on a new fast and parallel cross parameterization solver. The solver automatically computes as-isometric-as-possible cross maps across an entire corpus of examples and suggests to the user the best fitting (with the least distortion) given an input 3D shape. However, since the cross parameterization approach optimizes for minimal distortion globally, locally some meshing patterns can be scaled up or down if an extra feature is present on the input or (respectively) on the example extracted from the corpus.

### 2.3.2 PARTIAL SHAPE RETRIEVAL

In recent years, the problem of content-based shape retrieval (CBSR) has attracted the interest of scientists. The objective of such systems is to retrieve, from a given 3D query, the most similar 3D models from a given database; a similar issue consists in classifying a given shape into the correct category. This problem is not easy since, to be really efficient, such a retrieval/classification system has to be robust to common 3D shape variations like connectivity change, non-rigid deformation (isometry) **and has to be able to deal with partial queries** (a critical issue in our case).

A lot of methods have been introduced, based on global descriptors; some of them are only robust to rigid deformations [FMK03], while more recent ones are also invariant to non rigid deformations, like isometry or skeletal articulation [GSC07, Rus07, BBK09, MPS10]. **Even if these global descriptors provide a good invariance to non-rigid, quasi-isometric transforms, most of them are not adapted to deal with partial similarity.**

Hence, to face these hard robustness issues, some researchers turned their attention to local descriptors associated with salient feature points, following successful approaches in 2D image recognition like SIFT [Low04]. In such keypoint-based 2D image recognition techniques the object to recognize is represented by a set of salient local features (usually sparse) associated with local descriptors, then the recognition consists in finding a correspondence between the sets of feature points from the model and the scene objects respectively, using techniques like RANSAC. For 3D recognition, several authors have proposed such feature points detectors and descriptors [SOG09, SCF10, RPS09, APP09, SB11]. The retrieval task is then performed by finding a correspondence between feature points of the 3D models using some graph-matching techniques.

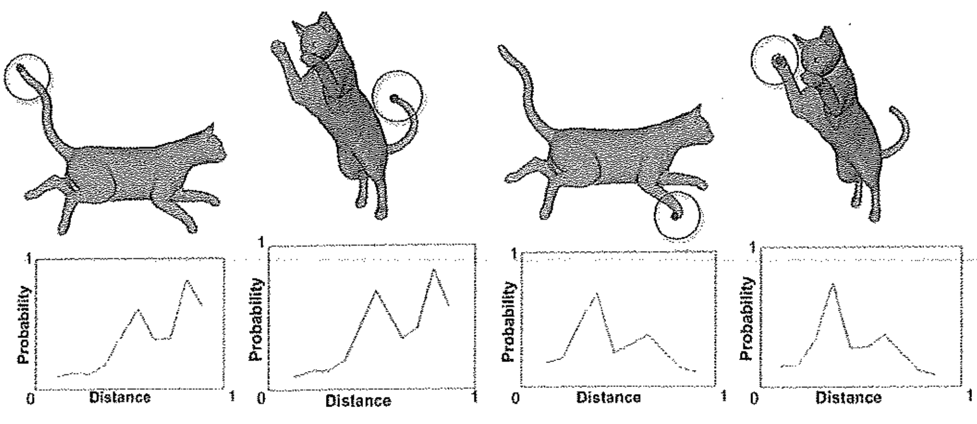


**Figure 2: Local descriptors (distribution of geodesic distances from feature point to all points of the mesh) on features points are invariant to rigid and non-rigid transformation of the surface [TDV11b]. The tail-located descriptors (a and b) are similar as well as the leg-located descriptors (c and d) even if the cat's pose changes.**

An alternative to this matching step is to consider a Bag of Words (BoW) approach like Bronstein et al. [BBG11]. In this kind of approaches, each feature point from a given model is associated to the nearest visual word in a given visual dictionary (we assume that the dictionary has been preliminary built using clustering techniques in the descriptor space); the 3D model is then represented as a histogram (i.e. the bag) of occurrences of the visual words.

There exist two main problems with these approaches based on 3D feature points: 1) the repeatability (i.e. the invariance in location) of salient feature points, regarding connectivity or topological changes is not so obvious and 2) the graph matching is often a quite complex process (inexact graph isomorphism is NP-complete) particularly for partial similarity (Sub-graph isomorphism). The BoW approach could be a solution for this latter problem but it has usually some difficulties to deal with partial queries because it computes a global descriptor.

Whereas some excellent works have recently been proposed for global shape correspondence [KLF11], **partial similarity remains an open issue particularly when the objects to compare have a different sampling density or connectivity** like raised in the SHREC 2011 contest [BBB11].

The involved teams from LIRIS, LIFL and LTCI have significantly contributed to the state of the art of shape retrieval and partial shape retrieval with several methods based on global descriptors [ADV07, EHB11], feature point matching [TVD09, TCD10, TDV11] and Bag of Words [Lav11, TDV11b]; these teams have also participated to the SHREC 2011 contest, track: Shape Retrieval on Non-rigid 3D Watertight Meshes.

### 2.3.3 CROSS PARAMETERIZATION

Once interesting examples have been identified through the shape retrieval process, their *geometric meta-data* (textures, animation skeleton, etc.) can be recycled onto the new input shape but it first requires a fitting step, to adapt the meta-data to the input. Such a fitting procedure refers to the more general problem of cross parameterization, i.e. finding an accurate point to point map between the two domains which alters as little as possible the meta-data (which introduces as little distortion as possible).

Many cross mapping algorithms have been proposed in the past. Given a set of corresponding landmarks between two surfaces of equivalent topology, existing techniques aim at interpolating this sparse correspondence all over the surfaces. Some algorithms have been specialized for specific topological classes (for discs [KSK98], for spheres [Alex99], for non-genus-0 surfaces [LBG08]). Other algorithms, using base meshes/domains [LDS99, KS04, SAP04] or surface fitting techniques [CLS11], handle homeomorphic surfaces of arbitrary topology. While they achieve cross-maps with low distortion, the main drawback of these algorithms is that they depend on landmark correspondences provided by the user; typically dozens for a pair of surfaces. While comparing to a database of examples, ensuring identical landmarks across all models is an arduous task.

Automatic computation of sparse reliable landmark correspondences is a challenging problem [LF09, ATC10]. It often requires a time-consuming exploration of the solution space, carried out for instance with Monte-Carlo strategies [LF09]. Recently, Kim et al. [KLF11] proposed to generate full one-to-one mappings by automatically blending multiple candidate maps computed by the sparse point correspondence algorithm by Lipman et al. [LF09]. However this algorithm still takes minutes to compute a cross map between two surfaces. In order to provide shortest response times, some partners of the project have proposed to explore the small space of as-isometric-as-possible cross maps with a multi-resolution gradient descent approach [TDN11]. Although it is not guaranteed to generate the optimal solution in general, under reasonable assumptions, it converges in a few seconds to a cross map with very low area and angle distortion.

Despite these recent advances in cross mapping, several research avenues remain open, especially in the context of meta-data fitting. First, cross mapping will always generate some distortion as long as the source and target surfaces are not identical. Current techniques aims at minimizing the global amount of distortion but it might be interesting for detail preservation to allow a control of the distortion repartition, in order to guarantee low distortion in important places (to preserve small important details in a texture for instance). Second, to the best of our knowledge, no automatic cross mapping algorithm has been proposed for volumetric data-sets. It is a needed component for volumetric meta-data fitting (animation skeletons, deformation cages, volumetric textures, etc.), where the ambient space embedding the meta-data needs to be deformed to fit the input.

### 2.3.4 PROJECT PARTNERS STATE OF THE ART ENTRIES.

- Example-based modeling support: [TDN11, TSS11]
- Shape retrieval [FVD05, FDV07, TVD09, Lav11, TDV11, TDV11b, EHB11]
- Cross parameterization [TDN11, TSS11]

## 2.4. POSITIONNEMENT DU PROJET / POSITION OF THE PROJECT

### 2.4.1 ADEQUATION AUX AXES THEMATIQUES DE L'APPEL

Ce projet se positionne naturellement et principalement dans **l'axe thématique 1** (Chaine de production, d'édition et de diffusion de contenu) puisque son objectif principal est **l'édition et la production de contenu graphique** 3D pour les domaines du loisir numérique (jeux vidéos, serious games, cinéma).

De manière secondaire, ce projet intègre également plusieurs aspects de l'axe 2 (des contenus aux connaissances), notamment sur deux points importants: 1) l'aspect **indexation** automatique et extraction de contenu 3D et 2) les aspects création et extrapolation de **nouveaux contenus** 3D et de méta-données à partir d'une base d'exemples.

### 2.4.2 POSITIONNEMENT VIS-A-VIS DU CONTEXTE NATIONAL ET INTERNATIONAL

La plateforme d'aide à la création de ressources graphiques visée par ce projet, n'a pour l'instant, à notre connaissance, pas d'équivalent dans le domaine industriel ni dans les projets de recherche actuels que ce soit au niveau national ou international.

Ce projet pourra bénéficier des avancées scientifiques du projet ANR MADRAS (2008-2011) auquel les partenaires LIFL et LIRIS ont participé sur le sujet de la segmentation de modèles 3D, son évaluation et son apprentissage. Bien que ces thématiques ne soient pas directement reliées au projet proposé, plusieurs résultats de MADRAS peuvent être réutilisés pour ses objectifs, tels que les méthodes de segmentation proposées.

Au niveau national, les principaux laboratoires impliqués dans les thématiques du projet (indexation 3D, apprentissage géométrique, paramétrisation) sont les trois laboratoires partenaires de cette proposition (LIFL, LIRIS and LTCI) ainsi que l'équipe INRIA ALICE du laboratoire LORIA de Nancy. Les projets ANR actuels les plus proches thématiquement de cette proposition sont l'ANR MORPHO sur l'analyse de maillages dynamique, l'ANR SEARCH sur l'acquisition et le réassemblage d'éléments 3D archéologiques et L'ANR SIMILAR-CITIES sur la création de textures procédurales pour les villes virtuelles. Bien que ces projets partagent quelques notions communes avec notre proposition (l'aspect indexation pour SEARCH, l'aspect analyse géométrique pour MORPHO et l'aspect création automatique de contenu pour SIMILAR-CITIES) leurs sujets restent largement éloignés de notre objectif.

Toujours au niveau national, ce projet s'inscrit dans les pôles de compétitivité *Imaginove* et *Cap-Digital*, pour lesquels des demandes de labellisation ont été effectuées.

Au niveau européen, les projets les plus proches de cette proposition sont l'ERC Goodshape porté par Bruno Lévy du LORIA et qui se focalise sur l'optimisation numérique pour la modélisation 3D et le projet FP7 Visionair qui porte sur les outils de visualisation et d'interaction 3D pour les données volumineuses issues de simulations scientifiques. Encore une fois, malgré quelques points communs, ces deux projets restent assez éloignés de notre proposition.

Enfin le projet proposé pourra s'intégrer dans le réseau d'excellence 3DLife auquel le partenaire LTCI appartient et qui comporte notamment des aspects indexation et génération de données 3D.

Au niveau international, deux laboratoires principaux travaillent sur des plateformes proches de notre proposition: l'équipe de Leonidas Guibas à Stanford ainsi que le Dynamic Graphics Project de l'université de Toronto.

## 2.5. MODIFICATION PAR RAPPORT A LA SOUMISSION PRECEDENTE / MODIFICATIONS REGARDING THE PREVIOUS SUBMISSION

Une première version du présent projet a été soumise à la précédente édition de l'appel ANR CONTINT en 2011. La proposition a été particulièrement bien accueillie, mais n'a malheureusement pas été financée à cause des deux principaux points faibles suivants :

1. Un manque d'expertise du consortium sur le volet *apprentissage automatique*, qui représentait une part importante du projet; avec notamment des aspects scientifiques trop flous dans ce domaine.

   ➔ Nous avons eu plusieurs discussions avec Philippe Preux qui dirige l'équipe INRIA SequeL de Lille, spécialisée en apprentissage automatique. Nous avons pu nous rendre compte que l'aspect apprentissage de notre projet était effectivement encore beaucoup trop prospectif pour pouvoir conduire à une réalisation à court terme. Nous avons donc décidé de supprimer cet aspect du projet afin de nous recentrer sur les deux aspects techniques présentant des perspectives de recherches et d'avancées précises : l'indexation partielle de modèles 3D et le transfert de meta-données, l'objectif étant d'avoir des prototypes intégrés à l'issu du projet.

2. L'absence de partenaires industriels plus impliqués dans le projet.

   ➔ Deux nouveaux partenaires financés ont intégré le projet : l'entreprise 3DDuo, spécialisée dans le *serious game* à Tourcoing, et la formation en jeux vidéo Gamagora de l'université Lumière Lyon 2.

Nous avons également rééquilibré le budget en missions et stagiaires comme demandé.

# 3. PROGRAMME SCIENTIFIQUE ET TECHNIQUE, ORGANISATION DU PROJET / SCIENTIFIC AND TECHNICAL PROGRAMME, PROJECT ORGANISATION

## 3.1. PROGRAMME SCIENTIFIQUE ET STRUCTURATION DU PROJET / SCIENTIFIC PROGRAMME AND PROJECT STRUCTURE

To achieve the goals we set on the project, the CrABEx project is divided into five main tasks, as illustrated in figure 3. Task-0 deals with the overall project management, and is lead by LIFL. Figure 4 illustrates the roles of each task within the whole project. For each task, one single task-leader has been co-opted by all the project partners. This task-leader guarantees that the corresponding deliverables will be provided on time. He commits himself with the will to manage a part of the project's activity, but refers to other partner teams (actually, all teams for almost all deliverables). All academic members of the project take part to all tasks. The Gamagora and 3DDUO partners are naturally involved in the data collection, the user-feedback and the integration process. Complementarities between the three academic partners together with their scientific and technical skills for the challenged problems are a testimony of success for the project.

**The management of the project is based on several conventions:**

- **A steering committee, composed by one member from each partner, is made.** Its goal is to make sure that the project's advancement follows the initial expectations, as stated in this document. Decisions in the steering committee shall be taken by consensus. If a consensus cannot be reached, decisions shall be taken by simple majority of all representatives. In cases of budget and resource (re-)allocation, determining a defaulting party, decisions on technical roadmaps, a majority of 75% of the votes is necessary. In cases, where no final decisions can be reached, the issue has to be brought to the attention of all project members for conclusion. The steering committee meets at least every six months.
- **Members of the projects meet at least once a year**, either in Lille, Lyon or Paris. During these meetings, an overview of all recent advances will be presented to all members of the project.
- **Co-advised PhD students meet both their advisors together at least once every three months.**

| Task | Leader | Other partners |
|---|---|---|
| T0 - Project organization and management | LIFL | LIRIS, LTCI 3DDuo, Gamagora |
| T1 - Data Collection | LTCI | LIFL, LIRIS 3DDuo, Gamagora |
| T2 - Partial Shape Retrieval | LIFL | LIRIS LTCI |
| T3 - Geometric Meta-Data Fitting | LTCI | LIRIS, LIFL |
| T4 - Integration, user-feedback | LIRIS | LIFL, LTCI 3DDuo, Gamagora |

**Figure 3: Tasks and corresponding partners.**

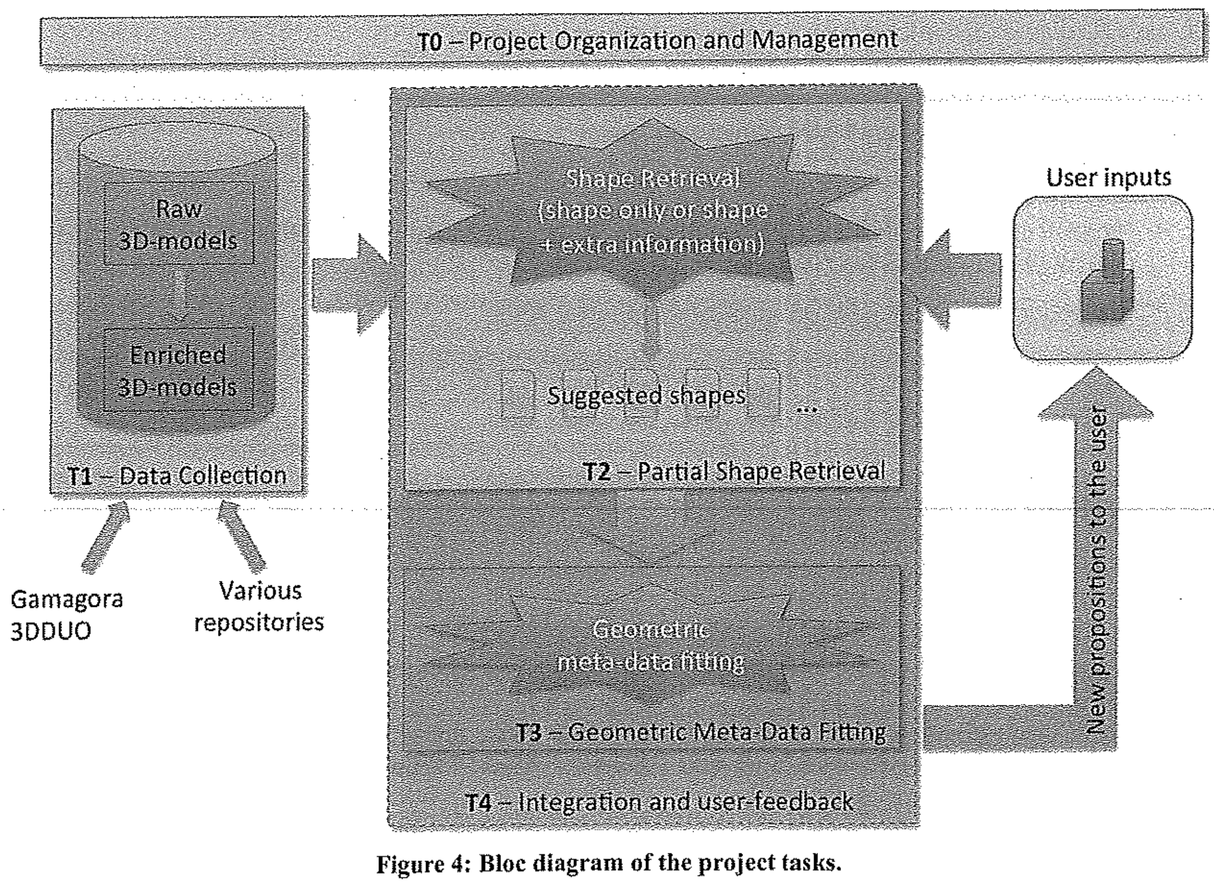


**Figure 4: Bloc diagram of the project tasks.**

## 3.2. DESCRIPTION DES TRAVAUX PAR TACHE / DESCRIPTION BY TASK

The project is divided into the five following tasks (including the project management task) that are described in details in the present section:

- Task-0: Project organization and management;
- Task 1: Data collection;
- Task-2: Partial-shape retrieval;
- Task-3: Geometric meta-data fitting;
- Task-4: Integration and user feedback.

### 3.2.1 TACHE 0 / TASK 0 – ORGANISATION ET MANAGEMENT DU PROJET / PROJECT ORGANIZATION AND MANAGEMENT

| Task-0 | Project organization and management |
|---|---|
| **Leader** | LIFL |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |
| **Starting date:** T0 | **Duration:** 48 months |

**Task description and objectives:** This task aims to ensure the communication between partners and the fulfillment of the tasks by enforcing the temporal constraints. The quality of each task is assured by each task-leader. The main goal is to guarantee the adequacy between the needs of pilot sites and the production of the researchers.

The coordination of the different tasks implies the following actions:

- Redaction of the consortium agreement between partners;
- Internal communication between the Contractors;
- Communication between the project and ANR (representation in audits, meetings, annual reports);
- Overall supervision of the project: monitoring the overall progress, the deliverables and milestones, the interrelations between tasks, etc;
- Detection of eventual problem and negotiation with ANR.

More detail about the project organization and management in the previous section.

This task does not contain any subtask.

### 3.2.2 TACHE 1 / TASK 1 – COLLECTION DES DONNEES / DATA COLLECTION

| Task-1 | Data Collection |
|---|---|
| **Leader** | LTCI |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |
| **Starting date:** T0 | **Duration:** 48 months |

**Task description and objectives:** The goal of this task is to gather and to format the database of 3D models along with their respective geometric meta-data (skeletons, cages, textures, etc.). To collect the raw input data, we consider 2 main scenarios.

A) First scenario

The first scenario of this task is to obtain the raw data from two members of the project: the computer video game school Gamagora and 3DDUO. They will provide to the project partners an unlimited and confidential access to the collection of models produced by its students or 3D designers. This collection is composed of models designed with 3DSMax and Maya. The amount of available models is estimated to 50 units.

B) Second scenario

It is expectable that not all of the models provided by Gamagora and 3DDUO will be directly exploitable for our project: some of them may have been designed with very early versions of 3DSMax and Maya, which may result in problems of import into the latest versions. Also, some of the models may have been designed with software that no longer exists today. Finally, it is expectable that some of the models are not challenging enough in term of geometry analysis (wall, very simple pieces of furniture, etc.) to be considered in our database. To complete the database, we will consider several sources including models freely available on the Web (with Creative Common Licenses or such, www.3dvia.com, Blender model repositories, etc.). We will also consider buying a moderate number of 3D models on online specialized shops (like www.turbosquid.com).

Once the initial data-set is collected (3D models plus geometric meta-data), we plan to enrich the collection with the help of students from Gamagora and 3D designers from 3DDUO, to design as many geometric meta-data as possible (to make sure that every entry in the database comes with a reasonable amount of meta-data).

The raw data (polygonal surfaces, textures maps, skeletons, skinning weights, etc.) will be converted into plain ASCII files in a format that will be later discussed.

This task is divided into 2 sub-tasks with corresponding deliverables.

| **Subtask-1.1** | Initial collection of 3D models |
|---|---|
| **Leader** | Gamagora |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |
| **Starting date:** T0 | **Duration:** 6 months |

**Task description and objectives:** This subtask will consist in:

- Collecting the raw data from Gamagora and 3DDUO as well as from the aforementioned model online repositories
- Converting the collection into plain ASCII files.

This task will be carried out by the two PhD students hired in the context of the project, continuously from the beginning of their thesis to its end. First, the priority will be given to populating and classifying the database with the model geometry. Then, the initial meta-data with each model will be integrated in the database.

At the end of this subtask, we expect a collection of 100 models coming with the initially available geometric meta-data.

**Deliverable:**

**D1.1 (T0+6):** Initial model collection with database format specification

| **Subtask-1.2** | Enriched collection of 3D models |
|---|---|
| **Leader** | LTCI |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |

| Starting date: T0+6 | Duration: 12 months |
|---|---|

**Task description and objectives:** This subtask will consist in:

- Completing the process of database populating initiated in the subtask 1.1
- Enriching the entries of the database which lack geometric meta-data

This task will be performed by the two PhD students in close relation with Gamagora and 3DDUO. The main goals of this task are to ensure a sufficient number of 3D models in the database, to make sure that each entry comes with a reasonable amount of geometric meta-data and to make sure that a satisfactory variety of geometric meta-data is available throughout the database. At the end of this subtask, we expect a collection of 150 models coming with the complete geometric meta-data. Even if the creation of this final database is fixed for T0+18, the addition of new models will be a continuous work until the end of the project.

**Deliverable:**

**D1.2 (T0+18):** Final model collection with complete geometric meta-data.

### 3.2.3 TACHE 2 / TASK 2 – INDEXATION PARTIELLE / PARTIAL-SHAPE RETRIEVAL

| Task-2 | Partial-shape retrieval |
|---|---|
| **Leader** | LIFL |
| **Partners** | LIFL – LIRIS – LTCI |
| **Starting date:** T0 | **Duration:** 36 months |

**Task description and objectives:** Partial-shape retrieval is obviously the first tool to use when creating new content with the help of an existing database. However, as raised in the state of the art, **robust partial similarity remains an open problem in the scientific community.**

To fulfill the requirements of the whole content creation framework, the proposed shape retrieval system have to own the following properties:

- Robustness to strong geometrical and topological changes (i.e. being able to recognize a model even if its pose has changed or even if its surface in not exactly the same as the query).

- Handling of partial query (the most critical issue regarding our application).

- Integration of attributes associated to the 3D models like color, texture or even higher level metadata.

- Reasonable computation time for the offline indexing part and **real time for the online retrieval step.**

To be able to satisfy this set of constraints, our objective is to rely on 1) efficient local descriptors associated with interest points or regions and 2) a smart graph matching algorithm able to integrate both local descriptors and spatial constraints between interest points or regions.

For the descriptor, we plan to investigate very informative descriptors inspired for instance by the Heat Kernel Signature [SOG09]. This signature has the drawback of not being robust to cropping (i.e. partial query) but a very interesting compact support version has been recently introduced at the conference SGP 2011[Rus11].

Our descriptors will be computed on salient feature points (hence the need of an accurate detector) or on regions extracted from a segmentation algorithm like those recently proposed by the members of the consortium [BLV11].

For the matching we plan to investigate the extension of recent graph matching algorithms like [ZBV09] to our specific partial matching (i.e. subgraph isomorphism) case.

One of the main issues will be **to cope with the real-time constraint**; indeed almost no existing method is able to handle this. We plan to investigate progressive methods that would be able to first provide a coarse retrieval result and then refine it.

Another critical issue will then **to integrate color, texture and even other metadata** to this partial matching framework. These data should reinforce the robustness and the accuracy of the results.

The development of this partial shape retrieval system will be mainly addressed by a PhD student co-advised by researchers from LIRIS and LIFL. **The thesis subject of this PhD student can be summarized as: "Progressive partial shape retrieval with attribute information.** This task is divided into 3 subtasks corresponding to deliverables.

| **Subtask-2.1** | State-of-the-art on 3D-shape and partial-shape retrieval |
|---|---|
| **Leader** | LIFL |
| **Partners** | LIFL – LIRIS – LTCI |
| **Starting date:** T0 | **Duration:** 6 months |

**Task description and objectives:** In order to correctly manage the partial-shape retrieval aspect of the project, it is mandatory to have a recent overview of 3D-shape retrieval methods (also called 3D-model indexing), existing since several years and of new 3D-partial shape retrieval approaches (which are really more recent). The use of color, texture and other metadata for indexing will also have to be investigated, although only few works exist in the state of the art.

The recent results of the SHREC contest could also provide quite relevant information complementary to this state of the art.

**Deliverable:**

**D1.1 (T0+6):** state-of-the-art written report

| **Subtask-2.2** | First prototype for partial shape retrieval |
|---|---|
| **Leader** | LIFL |
| **Partners** | LIFL – LIRIS – LTCI |
| **Starting date:** T0 + 6 months | **Duration:** 18 months |

**Task description and objectives:** The objective of this subtask is to develop a first version of the partial shape retrieval system, allowing to be able to test early its integration with the main other module of the platform: the merging engine coming from task 3.

In this first prototype the objective is to propose a simple and fast algorithm providing a correct accuracy; indeed the time constraint is critical for our system even more than the pure retrieval performance. This first prototype will focus on the geometry information rather than on the metadata or other texture or color attributes. To evaluate the performance of the system, we will use benchmarks from the SHREC contest and standard low-level measurements like the ROC curves.

**Deliverable:**

**D2.2 (T0+24):** Report and software

| **Subtask-2.3** | Final software for progressive partial shape retrieval |
|---|---|
| **Leader** | LIFL |

| Partners | LIFL – LIRIS – LTCI |
|---|---|
| **Starting date:** T0 + 24 months | **Duration:** 12 months |

**Task description and objectives:** This subtask aims at developing the final version of the partial shape retrieval system.

Regarding the first version from subtask 2.2, the idea is to extend the descriptor and the matching algorithm to integrate attribute data, particularly the texture/color information in order to boost the retrieval performance.

The second objective of this subtask is the integration of the coarse-to-fine retrieval mechanism to optimize again the processing time, particularly the online step which aims to be real-time. In the worst case scenario, if this progressive mechanism fails to be reliable, we will sacrifice some accuracy to keep a real-time performance.

This subtask will beneficiate from feedback outputs from the first integration tests conducted in Task 4. Once again the final retrieval system will be evaluated using benchmarks from the SHREC contests.

**Deliverable:**

**D2.3 (T0+36):** Report and software

### 3.2.4 TACHE 3 / TASK 3 – AJUSTEMENT DE META-DONNEES GEOMETRIQUES / GEOMETRIC META-DATA FITTING

| Task-3 | Geometric meta-data fitting |
|---|---|
| **Leader** | LTCI |
| **Partners** | LTCI – LIRIS – LIFL |
| **Starting date:** T0 | **Duration:** 36 months |

**Task description and objectives:** Once interesting examples have been identified through the shape retrieval process, their *geometric meta-data* (textures, animation skeleton, etc.) can be recycled onto the new input shape but it first requires a fitting step, to adapt the meta-data to the input. Such a fitting procedure refers to the more general problem of cross parameterization, i.e. finding an accurate point to point map between the two domains.

As raised in the state of the art section, several automatic algorithms have been proposed for surface cross parameterization. However, only few of them focused on time performance. Also, many existing techniques use simple intermediate canonical domains (sphere, plane) which can introduce a lack of precision in the correspondence around large protruding features (as raised in [TDN11]). Moreover, no cross mapping technique has been proposed to allow for a specific distortion repartition strategy, which can be useful to prioritize detail preservation in specific areas of the object. Finally, to the best of our knowledge, no algorithm has been proposed for volumetric cross parameterization. We propose to fulfill this lack with this task.

Our geometric meta-data fitting system would have to provide the following features:

- Support of surface-type (ex: textures) and volume-type meta-data (ex: skeletons).
- Automatic computations with editable results (such that the user can easily tune the result of the automatic suggestion)
- Support for user-driven or meta-data driven distortion guidance.
- Progressive computations supporting time constraints for interactive feedback.

To address these challenges, we will adopt a progressive strategy, first tackling surface cross-parameterization (1), and then volume cross-parameterization (2). In doing so, we will first focus on designing efficient and accurate algorithms supporting distortion guidance and driven by user defined landmark correspondences. Then, we will adapt the algorithm for the automatic computation of reliable landmarks, with a progressive computation scheme allowing for time constraint handling.

To develop efficient and accurate algorithms, we will start by investigating the possibility of cross-parameterization through the usage of adaptive canonical domains obtained by compatible segmentations of the shapes to cross map (for instance, with compatible parametric singularities at the extremities of prominent features). Then, we will investigate advances in optimal transport techniques to incorporate target distortion guidance. Afterwards, we will study global and/or local optimization schemes for the integration of automatic and implicit optimal placement of landmark correspondences.

The development of this geometric meta-data fitting system will be mainly addressed by a PhD student co-advised by researchers from LIRIS and LTCI. **The thesis subject of this PhD student can be summarized as: "Interactive and automatic transfer of geometric meta-data for 3D modeling support".** This task is divided into 3 subtasks corresponding to deliverables.

| **Subtask-3.1** | State-of-the-art on cross parameterization |
|---|---|
| **Leader** | LTCI |
| **Partners** | LTCI – LIRIS – LIFL |
| **Starting date:** T0 | **Duration:** 6 months |

**Task description and objectives:** In order to correctly manage the cross parameterization aspects of the project, it is mandatory to have a recent overview of cross parameterization methods. This report will review base-mesh based techniques [KS04, SAP04] and more recent canonical-domain based techniques [LBG08, KLF11, TDN11]. Also, since no volume cross parameterization algorithm has been proposed (to the best of our knowledge), the report will also briefly review volume parameterization (closely related).

**Deliverable: D3.1 (T0+6):** state-of-the-art written report

| **Subtask-3.2** | Prototype for surface-type geometric meta-data transfer |
|---|---|
| **Leader** | LTCI |
| **Partners** | LTCI – LIRIS – LIFL |
| **Starting date:** T0 + 6 months | **Duration:** 12 months |

**Task description and objectives:** The objective of this subtask is to develop a first version of the surface-type geometric meta-data transfer system. This task will be achieved according to the following schedule:

1) Automatic compatible segmentation from user defined landmarks
2) Integration of distortion guidance (first with a user-defined field, then with an automatic field computed from the analysis of the meta-data)
3) Integration of an automatic computation and implicit optimization of the landmarks
4) Development of a progressive scheme for time constraint integration

As a starting point, this work will be based on the triangle mesh cross-mapping algorithm published by the LTCI partner [TDN11]. Then, this algorithm will be extended according to the aforementioned schedule. In the worst case scenario, if the automatic computation of the landmark locations (the most hazardous task) fails to be reliable enough, we will use in the rest of the project sparse manual correspondences. To evaluate the performance of the system, we will use low-level measurements to validate that the output distortion repartition (angle and area) matches that of the target distortion. We will also use the benchmark described in [KLF11] to validate the automatic placement of landmarks.

**Deliverable: D3.2 (T0+18):** Report and software

| **Subtask-3.3** | Prototype for volume-type geometric meta-data transfer |
|---|---|
| **Leader** | LTCI |
| **Partners** | LTCI – LIRIS – LIFL |
| **Starting date:** T0 + 18 months | **Duration:** 18 months |

**Task description and objectives:** The objective of this subtask is to develop a first version of the volume-type geometric meta-data transfer system. This task will be achieved with the same methodology as the subtask 3.2:

1) Automatic compatible segmentation from user defined landmarks
2) Integration of distortion guidance (first with a user-defined field, then with an automatic field computed from the analysis of the meta-data)
3) Integration of an automatic computation and implicit optimization of the landmarks
4) Development of a progressive scheme for time constraint integration

The system will take as an input the output of the previous subtask (3.2): the surface correspondence will serve as constraints for the point-to-point correspondence of the ambient 3D space (discretely sampled as a regular grid). In the worst case scenario, if the subtask 3.2 fails at computing robustly fully automatic cross maps, manual user landmarks will be considered. To evaluate the performance of the technique, we will use low-level measurements to validate that the repartition of the output distortion (angles of the deformed voxels and area of their bounding cube) matches that of the target distortion.

The system will enable users to transfer volume-type geometric meta-data from one model to another, for instance: animation skeletons, deformation cages, accessories (clothes), extra-piece of geometry (for shape completion).

**Deliverable:**

**D3.3 (T0+36):** Report and software

### 3.2.5 TÂCHE 4 / TASK 4 – INTÉGRATION ET RETOUR UTILISATEUR / INTEGRATION AND USER-FEEDBACK

| **Task-4** | Integration and user-feedback |
|---|---|
| **Leader** | LIRIS |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |
| **Starting date:** T0 + 18 | **Duration:** 30 months |

**Task description and objectives:** This task is dedicated to the integration, the evaluation and the optimization of the content-creation platform which is the core of the project, in order to produce a fully integrated and *intelligent* system, able to provide, at runtime, smart suggestions to the designers.

The first objective of this task is to **early integrate the first developments** of the two previous tasks (shape retrieval and cross mapping) into **a working prototype** with a smart user interface. This prototype will be of great use for the other tasks by allowing to test the full system all along the development phases of the shape retrieval and cross mapping engines.

Then a second step will be dedicated to the evaluation of the platform. We plan to conduct **subjective evaluations** in the form of user tests since it is the only way to really measure the impact of the platform on the designers; moreover these subjective experiments will be the occasion to **observe and analyze the user behavior and interactions** and this information will be highly relevant to optimize the platform, in a third step.

This task will mainly be addressed by an engineer in cooperation with all the partners and especially with development engineer at 3DDUO and Gamagora.

This task is divided into 3 subtasks corresponding to deliverables.

| **Subtask-4.1** | First prototype integration |
|---|---|
| **Leader** | LIRIS |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |
| **Starting date:** T0+18 | **Duration:** 12 months |

**Task description and objectives:** It is critical for the good progress of the project to have soon a first prototype of the content-creation platform; the objectives of this prototype are: 1) to propose a first version of the user interface and 2) to integrate the first results of the retrieval and cross-parameterization engines which are scheduled for T0+24.

The hired engineer, located in LIRIS, will be in charge of this subtask in cooperation with the other partners and particularly PhD students working on tasks *retrieval* and *cross-parameterization*, and engineers at 3DDUO and Gamagora to facilitate the final integration in task 4.3.

**Deliverable:**

**D4.1 (T0+30):** Software

| **Subtask-4.2** | User study |
|---|---|
| **Leader** | LIRIS |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |
| **Starting date:** T0 + 30 months | **Duration:** 12 months |

**Task description and objectives:** Conducting user tests is an important issue for this project, in order to measure the impact of the platform and also to refine the designer needs in term of interface and functionalities. Such outputs will be of great importance for the development of the final platform.

This subjective evaluation is also of interest to analyze the user behavior and interactions, in order to integrate this knowledge in the final platform.

This subjective evaluation aims to be conducted by the hired engineer, with the help of several partners who already has knowledge on subjective experiments. This task will be carried out in collaboration with Gamagora and 3DDUO.

**Deliverable:**

**D4.2 (T0+42):** Report

| **Subtask-4.3** | Final prototype |
|---|---|
| **Leader** | 3DDUO |
| **Partners** | LIFL – LIRIS – LTCI – Gamagora – 3DDUO |

| **Starting date:** T0 + 30 months | **Duration:** 18 months |
|---|---|
| **Task description and objectives:** This subtask is the last part of the project; the objective is the final proposal for our content-creation platform.<br>The objective is to propose a platform which integrates the final versions of the retrieval and cross parameterization engines (scheduled for T0+36).<br>The final integration will be tackled by the whole consortium. Particular attention will be paid to the integration of the research work in the 3DDUO's game development platform *Casual Crossing Engine* for usability demonstration purposes, and in a plugin for 3D design software *Maya* used by students at Gamagora. | |
| **Deliverable:**<br>**D4.3 (T0+48):** Report and software | |

## 3.3. CALENDRIER / TASKS SCHEDULE

The diagram in figure 5 illustrates the schedule of the different subtasks. The first critical issue is to obtain at T0+6 a 3D database allowing to start the experimental work of tasks 2 and 3.

The next key *rendezvous* is T0+18; indeed the first prototype of cross-parameterization (3.2) has to be finished in order to be able to start the development of the first version of the platform scheduled for T0+30. This first version will integrate smoothly the first shape-retrieval prototype (2.2) starting T0+24.

Thanks to this first version of the platform, the subjective tests will be conducted and the final platform will be ready for T0+48, after integration of the final inputs of tasks 2 and 3 scheduled for T0+36.

The complete list of the deliverables is also summarized in the table 1 below.

**Table 1: list of deliverables.**

| | Name of the Deliverable | Type | Leader | Other participants | Date |
|---|---|---|---|---|---|
| 1.1 | Initial collection of 3D models | Database | Gamagora | All partners | T0+6 |
| 2.1 | State-of-the-art on 3D-shape and partial-shape retrieval | Report | LIFL | LIRIS, LTCI | T0+6 |
| 3.1 | State-of-the-art on cross parameterization | Report | LTCI | LIRIS, LIFL | T0+6 |
| 1.2 | Enriched collection of 3D models | Database | LTCI | All partners | T0+18 |
| 3.2 | Prototype for surface-type geometric meta-data transfer | Software | LTCI | LIRIS, LIFL | T0+18 |
| 2.2 | First prototype for partial shape retrieval | Software | LIFL | LIRIS, LTCI | T0+24 |
| 4.1 | First prototype integration | Software | LIRIS | All partners | T0+30 |
| 2.3 | Final software for progressive partial shape retrieval | Software | LIFL | LIRIS, LTCI | T0+36 |
| 3.3 | Prototype for volume-type geometric meta-data transfer | Software | LTCI | LIRIS, LIFL | T0+36 |
| 4.2 | User study | Report | LIRIS | All partners | T0+42 |
| 4.3 | Final prototype | Software | 3DDUO | All partners | T0+48 |

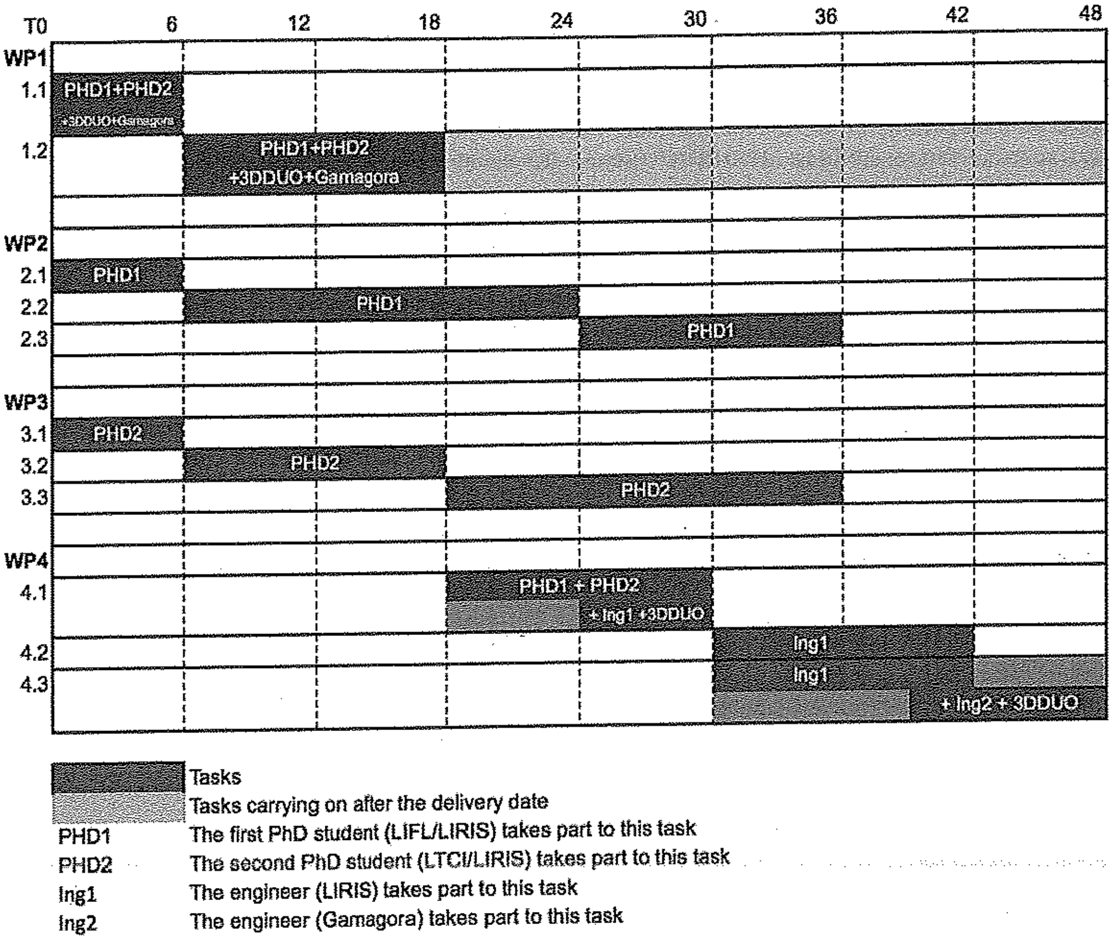


**Figure 5: tasks and planning.**

# 4. STRATEGIE DE VALORISATION, DE PROTECTION ET D'EXPLOITATION DES RESULTATS / DISSEMINATION AND EXPLOITATION OF RESULTS. INTELLECTUAL PROPERTY

As a research project, the expected results cover mostly a scientific outcome, but the Gamagora and 3DDUO partners will also insure that the technical results are practical for 3D-model designers and 3D *serious/learning game* agency.

## 4.1. GENERAL COMMUNICATION

The dissemination of the project information and evolution will be achieved by a dedicated web site. The main scientific problems of the project and the contributions will be available publicly. Thus everyone will be able to follow the progression of the project, the activity of the consortium meetings, the job offers (PhD, engineers…), etc. A private intranet will also be online for all the consortium members for internal communication.

## 4.2. SCIENTIFIC COMMUNICATION

This project aims to greatly improve the state-of-the-art of the different scientific domains involved (partial shape retrieval, cross parameterization). The list of deliverables (section 3.3) provides an indicator of the results expected at each step of the project.

Every significant advancement will be submitted to high-level international journals (such as ACM Transactions on Graphics, IEEE Transactions on Visualization and Computer Graphics, IEEE Transactions on PAMI, Computer Graphics Forum, etc.) and international conferences with a high-level scientific impact (like Eurographics, SGP, SPM, SMI).

We also plan to participate to several international contests to assess the different core contributions of the project such as future editions of SHREC (Shape Retrieval Contest) for partial shape retrieval methods developed in the framework of the project.

## 4.3. FUTURE INDUSTRIAL BENEFITS

We foresee industrial benefits of this research at several levels, mostly in design studios related to the entertainment industry.

First, the main target of example-based 3D modelling support is **to optimize the production pipeline of 3D content** (both in term of time delay and cost). Thus, it is expectable that the productivity of the studio designers will be greatly improved, thanks to the "recycling" potential of our framework.

Second, we believe that such an approach can lead to **new ways to envision team work in design studios.** Indeed, the expertise of experienced designers will be more accessible to novice designers, who will be able to easily reproduce an expert's style and to produce high quality designs as of the very early stages of their career.

Third, the envisioned system might also be seen to some extent as **a new pedagogic tool for teaching 3D modeling**, allowing professors to easily show and instantaneously integrate the "right things to do" on a model (based on the retrieved examples), whenever a student gets stuck in his/her design. This will be achieved by the development of a plugin in *Maya*, a 3D design software used at Gamagora. So, the benefit of our framework for teaching purposes will be evaluated with the Gamagora partner.

From a practical point of view, **the 3DDuo partner acknowledged the high impact of this research for its daily activity.** Throughout the project, we will closely work with this company to evaluate the impact of our system on its productivity. For this end, the research work will be integrated in the 3DDUO's game design and development platform *Casual Crossing Engine*.

In the long-term perspective, at the end of the project, we will consider the possibilities for **transferring the results of this research to the industry via plugins to industrial standard tools such as 3DSMax**. This transfer might be run in collaboration with user companies (such as the 3DDUO partner of course) and developing companies yet to identify (Dassault Systèmes for instance).

## 4.4. INTELLECTUAL PROPERTY

The partners will subscribe to a Consortium agreement. This agreement will be proposed by the project coordinator and will be negotiated, before the starting of the project. It will cover the principal structuring procedures of the project and will define the rules for the intellectual properties: knowledge and contribution previously of the project, works done into the project and so on.

Regarding the intellectual properties, the know-how developed during the project will be protected. The general results (including specifications, software architecture, etc.) and more generally the experimental results will be shared inside the consortium. A level of confidentiality will be defined for each of these materials.

The knowledge acquired previously to the project will remain the properties of their authors.

The software developed inside the project will be the properties of their authors.

Inside and during the project, the sharing of knowledge will be effective on a free basis. The sharing of sources of software will be done on case by case and in preserving the interest of their owners.

# 5. DESCRIPTION DU PARTENARIAT / CONSORTIUM DESCRIPTION

The CrABEx project is proposed by a consortium of three French academic partners, along with a computer video game school linked to Université Lumière Lyon 2, and a leading serious game agency. Each of the academic partners has an excellent background in 3D-mesh model analysis for compression, indexing, watermarking and segmentation. The three partners are the following:

1. LIFL – UMR 8022 Lille1/CNRS (MIIRE research group – project coordinator), Lille;
2. LIRIS – UMR 5205 CNRS (M2DisCo research group), Lyon;
3. LTCI – UMR 5141 CNRS, Telecom ParisTech, Paris;
4. Gamagora, ICOM, Université Lumière Lyon 2;
5. 3DDUO, Tourcoing.

## 5.1. DESCRIPTION, ADEQUATION ET COMPLEMENTARITE DES PARTENAIRES / PARTNERS DESCRIPTION, RELEVANCE AND COMPLEMENTARITY

The following four subsections present in detail each partner (history, research groups, main research interests and significant publications). The fifth subsection describes previous collaborations of the partners and the added value of the present consortium.

### 5.1.1 LIFL – UMR 8022 LILLE1/CNRS (MIIRE RESEARCH GROUP – PROJ. COORD.), LILLE

The MIIRE research group (http://www-rech.telecom-lille1.eu/miire) is a group from LIFL (UMR 8022 Lille1/CNRS) and TELECOM Lille 1 – an engineering school in the Information Society Technologies (IST) domain – on the campus of the University Lille1. LIFL (*Laboratoire d'Informatique Fondamentale de Lille* – http://www.lifl.fr) is the Computer Science Department of the University Lille1 and is supported by CNRS since its creation in 1983, in terms of a mixed research unit (UMR 8022 Lille1/CNRS). It is also a partner of INRIA Research Centre Lille - Nord Europe (http://www.inria.fr/centre/lille) since 2003.

The MIIRE research group has a strong expertise about 3D-model analysis for indexing (since 1999), topological skeleton extraction (since 2004) and segmentation (since 2008).

Concerning 3D-model indexing, the MIIRE research group has developed several methods since 1999, such as methods based on statistical analysis of 3D-meshe, and, within the framework of the RNRT SEMANTIC-3D project, a method to index 3D-models using 2D-views [LIFL-1]. This 3D-model indexing method is used in an on-line 3D-model search engine that could be tested at http://www-rech.telecom-lille1.eu/3dretrieval. Nowadays, the group still investigates the 3D-model indexing field and is developing new methods for non-rigid and partially similar models [LIFL-2].

Since 2004, the MIIRE research group is also interested in the topological analysis of 3D-mesh models in order to extract a semantic-oriented structure (as a graph) from such a 3D-mesh. The group has developed a method based on topological analysis of 3D-mesh and Reeb graphs to obtain an enhanced topological graph [LIFL-3]. This method has been used to produce high-level primitive for partial 3D-shape retrieval [LIFL-4].

At last, and since the last collaboration with LIRIS partner within the ANR MADRAS project, the MIIRE research group is concerned by 3D-mesh segmentation, with the development of a benchmark for the evaluation of segmentation methods [LIFL-5] and a new 3D-mesh segmentation method [LIFL-6].

The MIIRE research group is also involved in the recognition of 3D-faces and 3D facial expressions [LIFL-7]. On this topic, the group has several publications in international journals and conferences like IEEE PAMI, Visual Computer Journal, ICPR, ICCV, etc.

In the past, the MIIRE research group has been involved in many national and international partnerships, such as the RNRT SEMANTIC-3D project (2002 – 2006), the European Network of Excellence DELOS (2006 – 2009), the ANR FAR3D project (2008 – 2011), the ANR MADRAS project (2008 – 2011), the ANR-NSFC "3D Face Analyser" project (since 2011).

The members who take part to this project are the following:

| Person | Man-Month |
|---|---|
| Jean-Philippe Vandeborre (MC) | 30 |
| Hazem Wannous (MC) | 18 |
| Mohamed Daoudi (PR) | 6 |
| **Total** | **54** |

### 5.1.2 LIRIS –UMR 5205 CNRS (M2DISCO RESEARCH GROUP), LYON

The M2DisCo team (http://liris.cnrs.fr/m2disco) is a research group of the LIRIS laboratory (http://liris.cnrs.fr). The LIRIS (Lyon Research Center for Images and Intelligent Information Systems) was born at the beginning of year 2003, following the clustering of several computer science laboratories from Lyon. It has been associated to the French research institution CNRS under the label UMR 5205 and is mainly dedicated to image and information systems.

The M2DisCo research group (Multiresolution, Discrete and Combinatorial Models) is dedicated to indexing, compression and watermarking of 3D objects. The main issue of this team is the collaboration between analysis and modeling, in order to develop highly efficient and adaptive algorithms. Indeed when a 3D shape is well understood, its processing is far more efficient. M2Disco was ranked A+ by the French Evaluation Agency for Research and Higher Education (AERES). Its works are published in prestigious international journals and conferences (ACM Transactions on Graphics, ACM Transactions on Applied Perception, Computer Graphics Forum, Computer Aided Design, IEEE Transactions on multimedia, SMI, SGP, CGI).

In relation to task 2: the M2DisCo group owns a strong experience on surface analysis and description: several segmentation methods have been proposed [LIRIS-1] [LIRIS-2] and some 3D surface descriptors related to perception [LIRIS-3]. The team also worked recently on a robust shape retrieval algorithm based on bag-of-words [LIRIS-4] and has also a good background in 2D shape retrieval [LIRIS-5]

Regarding task 3, the team has developed an innovative filtering tool based on Minkowski operations which is of great interest for the data merging task of the project [LIRIS-6] [LIRIS-7].

The M2DisCo members involved in this projects are or have been involved in several national projects: RNRT SEMANTIC-3D (2002-2005) (project leader), RNTL SCOS (2006-2008), ANR MADRAS (2008-2011) (project leader) and ANR Collaviz (2009-2012).

The members who take part to this project are the following:

| Person | Man-Month |
|---|---|
| Guillaume Lavoué (MC) | 20 |
| Florent Dupont (PR) | 15 |
| Florence Denis (MC) | 15 |
| Vincent Vidal (MC) | 12 |
| Christian Wolf (MC) | 10 |
| **Total** | **72** |

### 5.1.3 LTCI – UMR 5141 CNRS, TELECOM PARISTECH (TII TEAM), PARIS

The TII team (http://perso.telecom-paristech.fr/~bloch/tii/) is a research team of the LTCI laboratory (http://www.ltci.telecom-paristech.fr/?lang=en). The LTCI ("Laboratoire Traitement et Communication de l'Information") was created in 1982 and has been associated to the French National Center for Scientific

Research (CNRS) in 2002. This laboratory covers all the research activities within Telecom ParisTech (http://www.telecom-paristech.fr/eng/training-innovating-in-a-digital-world.html), a leading engineering school in Information Technologies.

The TII team is dedicated to image analysis and understanding at large (knowledge representation and spatial reasoning, machine learning and image retrieval, computer vision, medical imaging), including 3D modeling and computer graphics. Since October 2008, 3 new permanent members (in order Tamy Boubekeur, Julien Tierny and Pooran Memari) joined the group to reinforce the research efforts in computer graphics in areas such as rendering, 3D modeling, geometry processing and visualization. The LTCI lab was ranked A+ and the TII team was ranked A in 2010 by the French Evaluation Agency for Research and Higher Education (AERES). The TII team has an important visibility at the international level in all of the research areas it covers, with publications in the major venues (ACM SIGGRAPH, IEEE VIS, Eurographics, ACM Trans. On Graphics, IEEE Trans. On Vis. And Comp. Graph., etc.) and participations to the program committees of the most selective international conferences (ACM SIGGRAPH, Eurographics, etc.).

With regard to the global scope of the project, the TII team has a strong expertise in 3D modeling with contributions in several areas, such as skeleton extraction [LTCI-1], re-meshing [LTCI-2][LTCI-3][LTCI-4], shape editing [LTCI-5], etc. In relation to task 2, some members of the TII team made several contributions to 3D shape retrieval with new algorithms for partial shape retrieval [LTCI-6] or retrieval by sketch queries [LTCI-7]. Thus, without being clear leaders in this specific area, the members of the TII team have the sufficient background to support the LIRIS and LIFL teams in this task.

With regard to task 3, some members of the TII team made several important contributions lately to surface cross parameterization with applications to surface quadrangulation re-use [LTCI-3] and geometric detail cloning [LTCI-5]. Example based 3D modeling support is a key priority of the group [LTCI-3, LTCI-5] and cross parameterization is a very active research topic of its members. Thus, the TII team will bring a leading expertise on this topic.

The TII team members are involved in many ANR projects (MediaGPU, KidPocket, CeCiL, FETUS, iSpace & Time, GV-Lex), European projects (3DLife) and industrial projects ("Chaire Imaginaire" Dassault Systeme, Ubisoft, Orange Labs, Peugeot-Citroen).

The members who take part to this project are the following:

| Person | Man-Month |
|---|---|
| Julien Tierny (CR) | 20 |
| Pooran Memari (CR) | 5 |
| **Total** | **25** |

### 5.1.4 GAMAGORA, ICOM, UNIVERSITÉ LUMIÈRE LYON 2

Gamagora is the Video Games and Digital Entertainment School of Université Lumière Lyon 2 – Université Claude Bernard Lyon 1. Gamagora first opened its doors in September 2007 and offers a Master's degree in interactive game technology and two graduate professional certificates in Level Design and Graphics Design and Artwork. This educational program benefits from the synergy of industry veterans, CNRS researchers and the sponsorship of the Pôle de Compétitivité Imaginove (Région Rhône Alpes). Gamagora is also supported by the LIRIS Laboratory, and in particular by the researcher of the LIRIS-GEOMOD Team which is ranked A + by AERES.

The proposed courses provide students with an expertise in real time computer graphics, level and game design, animation and graphics design. The purpose of Gamagora is to form high-level executives as well as technical experts well trained in production methods and aware of the latest innovations. The focus of training is based on three principles: (1) Replicate, in terms of education, the production processes that are used in the digital entertainment industry to make the students quickly operational; (2) Allow students to anticipate and absorb faster innovations to help companies to conquer or create new markets. (3) Train multidisciplinary students to a solid scientific background and artistic ability. This training is built on courses proposed by professional veterans in the digital image industry and researchers at the forefront of innovation.

Gamagora is primarily a triptych that binds teachers, businesses and research. In addition to the members of GAMAGORA involved in the project, three researchers of the LIRIS-GEOMOD team will bring a complementary expertise in the field of geometric modeling, in particular in mesh processing.

All the participants have a high expertise in the video game industry, were and are involved in different projects with the video game industry: GENAC 2 (FUI 2007-2010) related to procedural content generation in collaboration with Eden Games and WideScreen Games, Mango project (DGCIS funded project, 2012-2014) related to next gen game production in collaboration with Ubisoft, Robopopuli project (FUI 2012-2014) related to game design for end user applications with robots.

The members who take part to this project are the following:

| Person | Man-Month |
|---|---|
| Gilles Gesquières (PR) | 12 |
| Eric Galin (PR) | 12 |
| Olivier Mascleff (Coord. pédagogique) | 6 |
| **Total** | **30** |

### 5.1.5 3DDUO, Tourcoing

3DDUO is a development studio of digital & cross-media video games. 3DDUO is focused on the development of three kinds of games: serious games for sensitization, promotion, training sessions, casual games for the quick and easy entertainment, social games to gather people around a common passion.

3DDUO, founded in 2008, has a strong experience of video games development thanks to a team of 25 persons and customers like Dargaud, France Television, CNFPT, Cajoline, Moonscoop, Xilam, etc. 3DDUO has the JEI (*Jeune Entreprise Innovante*) status and is very involved in research & development. The company has already developed four projects of this type: *SPHERE* (AAP NKM) – a multiplayer web 3D online platform promoting the research results of the University Lille 1, in collaboration with the laboratories IRCICA and LIFL; *Handicohesion* (AAP NKM) – a serious game which sensitize to the integration of the disabled, in collaboration with the laboratory THIM; *Melting Bot* (Agrément CIR 2010-2011) – an engine which permit to develop massively multiplayer online web 3D games; *Casual Crossing Engine* (RIAM Oséo/CNC) – an evolution of Melting Bot which integrates new kind of games and the support new platforms.

Finally, 3DDUO has won numerous awards: first price of the *Concours de l'Institut Télécom*; coup de cœur of the *Concours TOTAL-EDHEC*; grand prix de l'innovation of the *Concours Graines de Boss* (by *M6* television and the *Jeune Chambre Economique France*) ; first price of the *Concours CréACC* (ordre des experts comptables) ; coup de cœur du *Concours du Jeune Créateur d'Emplois*; lauréat *Innovation Technologique du MITI*; lauréat *LMI (Lille Métropole Innovation)*; lauréat *Réseau Entreprendre Nord.*

The members who take part to this project are the following:

| Person | Man-Month |
|---|---|
| Maxence Devoghelaere (CEO) | 6 |
| Mario Howen Ying (Lead 3D Modeler) | 12 |
| Arnaud Berg (R&D Director) | 12 |
| Axel Guillummette (Lead animator & 3D Modeler) | 6 |
| **TOTAL** | **36** |

## 5.2. QUALIFICATION, ROLE ET IMPLICATION DES PARTICIPANTS / QUALIFICATION AND CONTRIBUTION OF EACH PARTNER

### 5.2.1 BIOGRAPHIE DU COORDINATEUR DU PROJET / PROJECT COORDINATOR'S BIOGRAPHY

**Jean-Philippe Vandeborre** (38 years old), the CrABEx project coordinator, received the M.Sc. degree in 1997 and the Ph.D. degree in 2002, both in Computer Science and both from University Lille1. He also holds the *Habilitation à Diriger des Recherches* – French post-doctoral degree allowing its holder to supervise PhD students and more generaly researches – since 2012 from University Lille1. Currently, he is an associate professor (*maître de conférences*) in Institut Mines-Telecom/Telecom Lille 1 and a member of the LIFL (UMR Lille1/CNRS 8022) since 2002. His research interests are mainly focused on three-dimensional model analysis, and include indexing and retrieval from content, 3D-mesh segmentation methods and automatic evaluation of segmentation quality. He is the co-author of 9 papers in high quality refereed journals (IEEE PAMI, IEEE TMM, Computer Graphics Forum, etc.) and more than 30 proceedings of high quality international conferences (ICME, ICPR, SMI, etc.). He was the co-supervisor of four PhD students (defended between 2006 and 2011) and on PhD student in progress (defense expected in 2013).

He has been involved in several French projects (RNRT SEMANTIC-3D (2002-2006), and especially ANR MADRAS project (2008-2011) in which he was the LIFL partner coordinator) and a European project (DELOS NoE). He also serves as program committee member and reviewer for international journals and conferences.

Five significant publications:

[1] H. Tabia, M. Daoudi, J-P. Vandeborre, O. Colot, A parts-based approach for automatic 3D-shape categorization using belief functions, ACM Transactions on Intelligent Systems and Technology (ACM TIST), Vol. 4, No. 2, 2013. (forthcoming issue)
[2] R. El Khoury, J-P. Vandeborre, M. Daoudi, Indexed heat curves for 3D-model retrieval, 21st IEEE International Conference on Pattern Recognition (ICPR 2012), November 11-15, 2012, Tsukuba Science City, Japan.
[3] H. Benhabiles, G. Lavoué, J-P. Vandeborre, M. Daoudi, Learning boundary edges for 3D-mesh segmentation, Computer Graphics Forum (selected for presentation at Eurographics 2012), vol. 30, No. 8, pp. 2170-2182, 2011.
[4] H. Tabia, M. Daoudi, J-P. Vandeborre, O. Colot, A new 3D-matching method of non-rigid and partially similar models using curve analysis, IEEE Transactions on Pattern Analysis and Machine Intelligence, volume 33, number 4, pp. 852-858, April 2011.
[5] J. Tierny, J-P. Vandeborre, M. Daoudi, Partial 3D-shape retrieval by Reeb pattern unfolding, Computer Graphics Forum - Eurographics Association - Ed. Blackwell, volume 28, number 1, pp. 41-55, March 2009.

### 5.2.2 BIOGRAPHIE DES PRINCIPAUX PARTICIPANTS / MAIN PROJECT PERSON'S BIOGRAPHIES

**Hazem Wannous** (37 years old) received the M.Sc. degree in Computer Science in 2005 from the University de Bourgogne, France and Ph.D. degree in image processing and computer vision from the University d'Orléans, France in 2008. Currently, he is an associate professor at the University Lille 1/Telecom Lille1. He is also a member of the Computer Science Laboratory in University Lille 1 (LIFL – UMR CNRS 8022). His research interests include machine learning, pattern recognition, video indexing, geometric vision and 3D Object retrieval. He is co-author of 3 papers in refereed journals and 15 conferences.

Five significant publications:

[1] R. Slama, H Wannous, M. Daoudi, "Extremal Human Curves: a New Human Body Shape and Pose Descriptor", accepted in the 10th IEEE International Conference on Auomatic Face and Guesture Recognition FG'13, Shanghai, China, April 22-26, (2013)
[2] H. Wannous, V. Dovgalecs, R. Mégret, M. Daoudi, "Place Recognition via 3D Modeling for Personal Activity Lifelog Using Wearable Camera", International Conference on MultiMedia Modeling (MMM 2012) Klagenfurt, Austria, January 4-6 (2012)

[3] H. Wannous, Y. Lucas, S. Treuillet, A. Mansouri, Y. Voisin, "Improving color correction across camera and illumination changes by contextual sample selection" Journal of Electronic Imaging 21, 2(2012) 023015-1–023015-14 (2012)
[4] H. Wannous, Y. Lucas, S. Treuillet, "Enhanced assessment of the wound-healing process by accurate multi-view tissue classification", IEEE Trans. Med. Imaging 30(2): 315-326 (2011)
[5] H. Wannous, S. Treuillet, Y. Lucas, "Robust tissue classification for reproducible wound assessment in telemedicine environments", Journal of Electronic Imaging. Vol. 19, No. 2, April (2010)

**Guillaume Lavoué** is an associate professor (34 years old, maître de conférences) in INSA of Lyon and a member of the LIRIS Laboratory since 2006. His research interests are mainly focused on 3D mesh analysis and processing (segmentation, compression, watermarking), 3D object retrieval, perception and human factors for computer graphics. He is the co-author of more than 20 papers in high quality refereed journals (Computer Graphics Forum, IEEE TMM, IEEE PAMI, ACM TAP, The Visual Computer, etc.) and more than 35 papers in proceedings of high quality international conferences (Eurographics, SGP, CGI, SMI, Web3D, etc.). Guillaume Lavoué is member of the IEEE Technical Committee on Human Perception in Vision, Graphics and Multimedia (SMC society) and key member of the "3D Rendering, Processing and Communications" Interest Group of the IEEE Multimedia Communication Technical Committee (ComSoc society).

Five significant publications:

[1] Lavoué, G., Combination of bag-of-words descriptors for robust partial shape retrieval, The Visual Computer, vol. 28, No. 9, pp. 931-942, 2012.
[2] Lavoué, G., A Multiscale Metric for 3D Mesh Visual Quality Assessment, Computer Graphics Forum (Proceedings of SGP 2011), vol. 30, No. 5, pp. 1427-1437, 2011.
[3] H. Benhabiles, G. Lavoué, J-P. Vandeborre and M. Daoudi, Learning boundary edges for 3D-mesh segmentation, Computer Graphics Forum (selected for presentation at Eurographics 2012), vol. 30, No. 8, pp. 2170-2182, 2011.
[4] Lavoué, G., Corsini, M., A comparison of perceptually-based metrics for objective evaluation of geometry processing, IEEE Transactions on Multimedia, Vol. 12, No. 7, pp. 636-649, 2010.
[5] Lavoué G., A Local Roughness Measure for 3D Meshes and its Application to Visual Masking, ACM Transactions on Applied Perception, Vol. 5, No.4, Article 21, 2009.

**Florent Dupont** (44 years old) received his B.S. and M.S. degree in 1990, and his Ph.D. in 1994 from "Institut National des Sciences Appliquées" of Lyon, France. He became Associate Professor in 1998. He is now Full Professor in the Multiresolution, Discrete and Combinatorial Models (M2DisCo) team of the LIRIS Laboratory (UMR 5205 CNRS) in the "Université Claude Bernard Lyon1", France. His technical research concerns 3D digital image processing and computational geometry. He published more than 80 papers on international journals or conferences. Florent Dupont lead the M2DisCo Team from 2006 to 2011. He is now deputy director of LIRIS.

Five significant publications:

[1] R. Arcila, C. Cagniart, F. Hétroy, E. Boyer, F. Dupont. Segmentation of temporal mesh sequences into rigidly moving components, Graphical Models, 2012.
[2] V. Vidal, C Wolf, F. Dupont. Combinatorial Mesh Optimization, The Visual Computer 28(5):511-525, 2012.
[3] H. Lee, G Lavoué, F. Dupont, Rate-distortion optimization for progressive compression of 3D mesh with color attributes, The Visual Computer 28(2):137-153, 2012.
[4] Barki H., Denis F., Dupont F.: "Contributing Vertices-Based Minkowski Sum of a Non-Convex--Convex Pair of Polyhedra", ACM Transactions on Graphics (TOG) 30(1):3:1-3:16, 2011.
[5] H. Lee, C. Dikici, G Lavoué, F. Dupont. The Visual Computer (within best 35 papers of CGI 2011) 27(6-8):781-792, 2011.

**Florence Denis** (50 years old) received the B.S. degree in 1983, the M.S. degree in 1985 and the Ph.D. degree in 1990, all from "Institut National des Sciences Appliquées" of Lyon, France. She is currently an Associate Professor at "Université Claude Bernard Lyon 1", France and member of the Multiresolution, Discrete and Combinatorial Models (M2DisCo) team of the image processing group at the LIRIS Laboratory. Her current research interests are in the fields of 2D and 3D image processing and analysis, 3D and 3D+t mesh analysis, and processing (including mesh reconstruction, mathematical morphology, watermarking and compression).

Five significant publications:

[1] Wang K., Lavoué G., Denis F., Baskurt A. - Robust and blind mesh watermarking based on volume moments. Computers & Graphics 35(1):1-19, Elsevier. 2011.
[2] Barki H., Denis F., Dupont F. - Contributing Vertices-Based Minkowski Sum of a Non-Convex--Convex Pair of Polyhedra . ACM Transactions on Graphics (TOG) 30(1):3:1-3:16, ISSN 0730-0301. 2011.
[3] Barki H., Denis F., Dupont F. - Contributing vertices-based Minkowski sum computation of convex polyhedra. Computer-Aided Design 41(7):525-538, ISSN 0010-4485. 2009.
[4] Wang K., Lavoué G., Denis F., Baskurt A., - Hierarchical Watermarking of Semi-regular Meshes Based on Wavelet Transform, IEEE Transactions on Information Forensics & Security, 3(4):620-634, 2008.
[5] Wang K., Lavoué G., Denis F., Baskurt A., - A comprehensive survey on three-dimensional mesh watermarking, IEEE Transactions on Multimedia. 10(8):1513-1527, 2008

**Vincent Vidal** (28 years old) graduated as an engineer from computer science department of École Nationale Supérieure d'Informatique et de Mathématiques Appliquées de Grenoble (ENSIMAG, part of National Polytechnic Institute of Grenoble), France, in 2007. He received his master's degree in computer science from Joseph Fourier University (UFR-IMAG, Grenoble), France, in 2008, and his PhD degree in computer science from the National Institute for Applied Sciences (INSA de Lyon), France, in 2011. Since 2008, he has conducted his research activities within the M2Disco team of the LIRIS laboratory in Lyon, France, and he has taught at the Claude Bernard University Lyon 1. He works as assistant professor at the Institut Universitaire de Technologie of Lyon 1 since September 2012. His research interests include geometry processing, mesh segmentation, measures of mesh quality, and probabilistic graphical models.

Five significant publications:

[1] V. Vidal, C Wolf, F. Dupont. Combinatorial Mesh Optimization, The Visual Computer 28(5):511-525, 2012.
[2] V. Vidal, C Wolf, F. Dupont. Mesh Segmentation and Global 3D Model Extraction. Symposium on Geometry Processing (SGP), poster, 2012.
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**Julien Tierny** (30 years old) received the Ph.D. Degree in Computer Science from Lille 1 University in October 2008. He is currently a CNRS permanent researcher at the LTCI laboratory of Telecom ParisTech, Paris, France. Prior to his CNRS tenure, he held a Fulbright fellowship (US Department of State) and was a post-doctoral research associate at the Scientific Computing and Imaging Institute of the University of Utah. His research interests include topological and geometrical data analysis for scientific visualization and computer graphics. Since 2006, he co-authored more than 20 scientific publications, including 11 journal papers in top venues such as ACM SIGGRAPH (ACM Transactions on Graphics) and IEEE VIS (IEEE Transactions on Visualization and Computer Graphics). He served in 2010 as an editor for a book published by Springer on Topological Techniques for Scientific Visualization. He also serves as a reviewer (ACM SIGGRAPH, IEEE VIS, EuroVis, Eurographics, etc.) and as an International Program Committee member (Eurographics SP 2012-2013, EuroVis SP 2013) for premiere quality scientific venues, as well as a Ph.D. committee member or funding agencies reviewer.

Five significant publications:

[1] J. Tierny, V. Pascucci: "Generalized Topological Simplification of Scalar Fields on Surfaces", IEEE Transactions on Visualization and Computer Graphics, Proc. of IEEE VIS 2012 (journal paper).
[2] B. Summa, J. Tierny, V. Pascucci: "Panorama Weaving: Fast and Flexible Seam Processing", ACM Transactions on Graphics, Proc. of ACM SIGGRAPH 2012 (journal paper).
[3] J. Tierny, A. Gyulassy, E. Simon, V. Pascucci: "Loop Surgery for Volumetric Meshes: Reeb Graphs Reduced to Contour Trees", IEEE Transactions on Visualization and Computer Graphics, Proc. Of IEEE VIS 2009 (journal paper).
[4] J. Tierny, J. Daniels, G. Nonato, V. Pascucci, C. Silva: "Interactive Quadrangulation with Reeb Atlases and Connectivity Textures", IEEE Transactions on Visualization and Computer Graphics, 2011 (journal paper).
[5] J. Tierny, J.P. Vandeborre, M. Daoudi: "Partial 3D Shape Retrieval by Reeb Pattern Unfolding", Computer Graphics Forum 2009 (journal paper).

**Gilles Gesquière** (41 years old) is Professor in computer graphics. Gilles Gesquière received his PhD in 2001 in the geometric modeling field in Université de Bourgogne. Then he joined the LSIS lab in Université d'Aix- Marseille as assistant professor for ten years. Since 2012, September, he is professor at Université Lyon 2, LIRIS and teacher in gamagora in geometric modeling. During these years, Gilles Gesquière continued to work on geometric modeling with applications on various fields as GIS, BIM, astronomy, medical imaging and Computer aided Design. In particular several project lead to work on 3D data exchange, interoperability, standards (OGC, ISO/ TC 211). Numerous projects have been done in industrial contexts (Geomatys, CEA, SII, Pixxim, C4W …).

Five significant publications:

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[5] Bénière.R, Subsol G., Gesquière G., Le Breton F., Puech W., « Recovering Primitives in 3D CAD meshes », SPIE, San Francisco, 01/2011.

**Eric Galin** (42 years old) is a Professor of Computer Science at the University Lumière Lyon 2, France. He received an engineering degree from Ecole Centrale de Lyon in 1993 and a PhD in Computer Science from Université Claude Bernard Lyon 1 in 1997. He is responsible for Gamagora, a high level education program combining Level Design, Graphics Design and Computer Game Programming tracks. This educational program benefits from the synergy of industry veterans, CNRS researchers and the sponsorship of the Pôle de Compétitivité Imaginove (Région Rhône Alpes).

His research interests include procedural modeling of virtual worlds, simulating natural phenomena and modeling with implicit surfaces. In collaboration with Brian Wyvill (University of Calgary, Canada), his research in implicit surface modeling came to the development of a hierarchical modeling system (the Hybrid Tree) which combines implicit surfaces and triangle meshes in a coherent and unified system. In the last eight years, his work has centered around modeling of virtual worlds which encompasses procedural model generation, natural phenomena simulation and virtual aging and weathering. In collaboration with Bedrich Benes (University of Purdue, USA), this research came to the development of a framework for generating virtual world (Arches) which has also served in several projects involving the video game industry (Eden Games and WideScreen Games in GENAC2, Ubisoft in MANGO). All the techniques described in the following publications have been implemented in the Arches framework. [1] and [4] where developed in collaboration with Eden Games and WideScreen Games and integrated to their video game pipeline.

Five significant publications:

[1] A. Peytavie, E. Galin, J. Grosjean, S. Mérillou, « Arches: a Framework for Modeling Complex Terrains", Computer Graphics Forum (Proceedings of Eurographics), 28(2), 457-467, 2009.
[2] A. Peytavie, E. Galin, J. Grosjean, S. Mérillou, « Procedural Generation of Rock Piles Using Aperiodic Tiling", Computer Graphics Forum (Proceedings of Pacific Graphics, 28(7), 1801-1809, 2009.
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**Maxence Devoghelaere** (27 years old) is the CEO of 3DDUO. Maxence is graduated from Télécom Lille1 and received a Master degree in Entrepreneurship and Management of the Innovation from IAE Lille. Before 3DDUO, Maxence has created the Association IDEO which developed an asynchronous online web game and has worked in Ankama as project manager on the software tools for the video game Dofus. Maxence is also President of Lille Metropole Innovation and Vice-President of the CEPIM (Club des Entreprises de la Plaine Images).

**Mario Howenying** (27 years old) is graduated from Creapole in 2007 and has been working in 3DDUO since March 2008 as Lead 3D Modeler.

**Arnaud Berg** (28 years old) is graduated from Polytech Paris Sud in 2007 and has been an associate of 3DDUO since March 2008 as R&D director.

### 5.2.3 PARTICIPATIONS DANS D'AUTRES PROJETS, PRESENTS ET PASSES (MOINS DE DEUX ANS)

| **Partenaire / Partner** | **Nom des personnes impliquées / Name of involved people** | **Intitulé du projet, source de financement, montant attribué / Project name, financing institution, grant allocated** | **Dates de début et de fin / Start and end dates** | **Liens avec le projet proposé / Links with the proposed project** |
|---|---|---|---|---|
| N°1 & 2 | F. Dupont (coordinator), G. Lavoué, F. Denis, V. Vidal, J-P. Vandeborre, M. Daoudi | **ANR Madras** – 3D Models and dynamic models representation and segmentation<br>Partners: LIRIS (coord.), LIFL, INRIA-Grenoble<br>143k€ for LIRIS, 172k€ for LIFL | 01/01/2008 – 30/09/2011<br>(completed) | Focus on a different topic (mesh segmentation). Some useful insights on subjective tests and learning methods. Segmentation algorithms can be useful for the proposed project. |
| N°2 | G. Lavoué (coordinator), F. Dupont | **Projet Lyon Science Transfert** – Maturation de Projets Innovants : Web 3D Streaming<br>60k€ for LIRIS | 01/01/2013 - 01/01/2014<br>(in progress) | Integration of texture in progressive mesh compression method. No significant link with the proposed project. |
| N°2 | F. Dupont, G. Lavoué, F. Denis | **ANR Collaviz** – open source plateform for remote collaborative multi-domain pre/post-processing<br>Academic partners: ECP, EGID, INPT, Insa-Rennes, LIRIS, Scilab + 11 industrial partners (EDF, Oxalya, Distene, etc.)<br>212k€ for LIRIS | 01/09/2009 – 30/06/2012<br>(completed) | No significant link with the proposed project. |

| | | | | |
|---|---|---|---|---|
| N°2 | F. Dupont, F. Denis | **PEPS ImagEar** – Méthodes d'analyse et de reconstruction tri-dimensionnelle d'images numériques ultrarésolues issues de coupes sériés de l'organe de l'audition<br>19k€ for LIRIS | 01/01/2010 – 31/12/2011 (completed) | No significant link with the proposed project. |
| N°3 | J. Tierny, P. Memari | **Projet DIGITEO – unTopoVis**<br>Grant for a 18 month Postdoc | 01/05/2013 – 30/04/2015 (in progress) | No significant link with the proposed project. |
| N°4 | E. Galin (coordinator), G. Gesquière | **Projet FUI RoboPopuli**<br>Avec les sociétés Awabots, Artefacts Studio, Gostai, Pob Tech et le laboratoire ENSTA ParisTech | 2012 – 2014 (in progress) | No significant link with the proposed project. |

# 6. JUSTIFICATION SCIENTIFIQUE DES MOYENS DEMANDES / SCIENTIFIC JUSTIFICATION OF REQUESTED RESSOURCES

Nous décrivons et justifions dans cette partie du document l'ensemble des financements demandés par chacun des partenaires.

## 6.1. PARTENAIRE 1 / PARTNER 1 : LIFL – UMR 8022 LILLE1/CNRS (MIIRE RESEARCH GROUP – PROJECT COORDINATOR), LILLE

Le LIFL demande **133 000 euros**, hors frais de gestion, détaillés comme suit.

- *Équipement / Equipment*

Dans le cadre de ce projet, le LIFL ne demande aucun investissement en équipement d'une valeur supérieure ou égale à 4000 euros.

- *Personnel / Staff*

Le LIFL demande le financement d'une thèse (**en co-encadrement avec le LIRIS**) en rapport avec la tâche numéro 2 (indexation par parties). Le coût total estimé de la rémunération d'un doctorant sur une période de trois ans est de **93 000 €** (gestion par l'Université Lille 1).

- *Prestation de service externe / Subcontracting*

Néant.

- *Missions / Travel*

Pour les missions, le LIFL demande **16 000 €** ; cette somme correspond aux nombreux échanges entre le LIFL et les autres partenaires pour les réunions et le co-encadrement de la thèse avec le LIRIS (environ 10 échanges, avec en moyenne 3 personnes et un coût unitaire moyen de 200 €). Quelques actions spécifiques de promotion du projet et de publication seront menées dans des congrès internationaux (environ 5 déplacements de 2 000 €).

- *Dépenses justifiées sur une procédure de facturation interne / Costs justified by internal procedures of invoicing*

Néant.

- *Autres dépenses de fonctionnement / Other expenses*

En ce qui concerne le petit matériel, le LIFL demande **20 000 €**; cette somme financera un serveur de données (site web, intranet, échanges de données au sein du projet, etc.) et 5 postes de travail (équipement informatique de l'ordre de 3k€ l'unité) nécessaires aux personnels directement impliqués et autres stagiaires. Des achats de consommables (CD/DVD, livres, abonnements, licences de logiciel, petites fournitures, etc.) complètent la demande.

Le LIFL demande également **4 000 €** pour l'embauche de stagiaires afin de servir de support aux différentes tâches du projet. Cette somme correspond à 2 stages d'une durée de 6 mois.

## 6.2. Partenaire 2 / Partner 2 : LIRIS – UMR 5205 CNRS (M2DisCo research group), Lyon

Le Liris demande **104 000 €** euros, hors frais de gestion, détaillés comme suit.

- *Équipement / Equipment*

Dans le cadre de ce projet, le LIRIS ne demande aucun investissement en équipement d'une valeur supérieure ou égale à 4000 euros.

- *Personnel / Staff*

Le LIRIS demande également un financement de 18 mois d'ingénieur expérimenté (de 3 à 5 ans d'expérience), l'objectif sera également de travailler sur le WP4 et plus précisément sur le développement de la première version de la plateforme.

Le coût pour ce financement ingénieur est de **72 000 €** (18 mois x 4000 €)

- *Prestation de service externe / Subcontracting*

Néant

- *Missions / Travel*

Pour les missions, le LIRIS demande **18 000 €** ; cette somme correspond aux nombreux échanges entre le LIRIS et les autres partenaires pour les réunions et le co-encadrement de deux thèses (environ 16 échanges, avec en moyenne 3 personnes et un coût unitaire moyen de 200€). Quelques actions spécifiques de promotion du projet et de publication seront menées dans des congrès internationaux (environ 4 déplacements de 2000€).

- *Dépenses justifiées sur une procédure de facturation interne / Costs justified by internal procedures of invoicing*

Néant

- *Autres dépenses de fonctionnement / Other expenses*

En ce qui concerne le petit matériel, le LIRIS demande **10 000 €**; cette somme financera 3 postes de travail (équipement informatique de l'ordre de 3k€ l'unité) nécessaires aux personnels directement impliqués et autres stagiaires. Des achats de consommables (CD/DVD, livres, abonnements, licences de logiciel, petites fournitures, etc.) complètent la demande.

Le LIRIS demande également **4 000 €** pour l'embauche de stagiaires afin de servir de support aux différentes tâches du projet. Cette somme correspond à 2 stages d'une durée de 6 mois.

## 6.3. Partenaire 3 / Partner 3 : LTCI – UMR 5141 CNRS (TII research group), Paris

Le LTCI demande **146 737,05 euros**, hors frais de gestion, détaillés comme suit.

- *Équipement / Equipment*

Néant.

- *Personnel / Staff*

Le LTCI demande le financement d'une thèse (**en co-encadrement avec le LIRIS**) en rapport avec la tâche numéro 3 (ajustement de méta-données géométriques). Le coût total estimé de la rémunération d'un doctorant sur une période de trois ans est de **117 337,05 €** (3 * 39 112,35€, gestion par Télécom ParisTech).

- *Prestation de service externe / Subcontracting*

Néant.

- *Missions / Travel*

Pour les missions, le LTCI demande **8 400 €** ; cette somme correspond aux nombreux échanges entre le LTCI et les autres partenaires pour les réunions et le co-encadrement de la thèse avec le LIRIS : environ 8 échanges (pour deux personnes) à un coût unitaire moyen de 150€. Quelques actions spécifiques de promotion du projet et de publication seront menées dans des congrès internationaux (un déplacement international par année de la thèse de 2 000€, frais d'hébergement et d'enregistrement aux conférences inclus).

- *Dépenses justifiées sur une procédure de facturation interne / Costs justified by internal procedures of invoicing*

Néant

- *Autres dépenses de fonctionnement / Other expenses*

Concernant les dépenses de fonctionnement, le LTCI demande **17 000 €**; cette somme financera : un poste de travail informatique nécessaire au doctorant co-encadré avec le LIRIS (2000 €), une licence pour un logiciel professionnel de modélisation 3D (par exemple 3DSMax) (5000 €), l'achat de 100 modèles 3D complets avec méta-données géométriques (100€ l'unité) auprès de sites Internet spécialisés (par exemple : www.turbosquid.com) pour l'alimentation de la base de données **qui sera exploitée dans tout le projet et par tous les partenaires impliqués** (10000 €)

Le LTCI demande également **4 000 €** pour l'embauche de stagiaires afin de servir de support aux différentes tâches du projet. Cette somme correspond à 2 stages d'une durée de 6 mois.

## 6.4. Partenaire 4 / Partner 4 : Gamagora, ICOM, Université Lumière Lyon 2

Gamagora demande **44 000 euros**, hors frais de gestion, détaillés comme suit.

- *Équipement / Equipment*

Dans le cadre de ce projet, Gamagora ne demande aucun investissement en équipement d'une valeur supérieure ou égale à 4000 euros.

- *Personnel / Staff*

Un ingénieur sur une période de neuf mois prendra part à la validation de la plateforme et à la préparation des jeux de tests en début de projet. Il guidera les étudiants et les partenaires de Gamagora lors de leurs évaluations de la plateforme. Il facilitera aussi les contacts avec les autres partenaires du projet. Le coût de ces 9 mois ingénieurs s'élève à **30 000 euros** (9 x 3 333 euros bruts chargés mensuels).

- *Prestation de service externe / Subcontracting*

Néant.

- *Missions / Travel*

Pour les missions, Gamagora demande **8 000 €** pour les 4 ans; cette somme correspond aux déplacements à prendre en compte lors de ce projet à plusieurs partenaires ainsi que la dissémination scientifique et pédagogique nécessaire à ce projet.

- *Dépenses justifiées sur une procédure de facturation interne / Costs justified by internal procedures of invoicing*

Néant

- *Autres dépenses de fonctionnement / Other expenses*

En ce qui concerne le petit matériel, Gamagora demande **6 000 €** pour l'embauche de stagiaires afin de servir de support aux différentes tâches du projet. Cette somme correspond à 4 stages d'une durée de 3 mois (en particulier des infographistes). Gamagora ne demande pas de machines sur ce projet.

## 6.5. Partenaire 5 / Partner 5 : 3DDUO, Tourcoing

3DDUO demande **56 386 €**, hors frais généraux, détaillés comme suit.

- *Équipement / Equipment*

Néant.

- *Personnel / Staff*

3DDUO demande la prise en charge à 45% des 4 personnes pour ce projet :

Maxence DEVOGHELAERE (6 mois), pour l'encadrement, le suivi de projet et les différentes réunions d'organisation soit **8 910€** (45% * 3300 * 6)

Mario HOWENYING (12 mois) et Axel GUILLUMMETTE (6 mois) pour le tri des assets 3D, la modélisation de nouveaux modèles nécessaires pour les tests et les différentes expérimentations soit **19 656€** (45% * (2450 * 12 + 2380 * 6))

Arnaud BERG (12 mois) pour l'intégration technique du projet à la plateforme *Casual Crossing Engine* afin de pouvoir utiliser directement les résultats de la recherche dans le pipeline de production de 3DDUO soit **17 820€** (45% * 3300 * 12)

- *Prestation de service externe / Subcontracting*

Néant.

- *Missions / Travel*

Pour les missions, 3DDUO demande **10 000 €** pour les 4 ans; cette somme correspond aux déplacements à prendre en compte lors de ce projet à plusieurs partenaires ainsi que la participation à des congrès spécialisés sur le jeu vidéo et la 3D.

- *Dépenses justifiées sur une procédure de facturation interne / Costs justified by internal procedures of invoicing*

Néant.

- *Autres dépenses de fonctionnement / Other expenses*

Néant.

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- *Personal bibliography for LIFL partner (section 5.1.1)*

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[LIFL-2] Tabia T., Daoudi M., Vandeborre J-P., Colot O., "A new 3D-matching method of non-rigid and partially similar models using curve analysis", IEEE Transactions on Pattern Analysis and Machine Intelligence, volume 33, number 4, pp. 852-858, April 2011.

[LIFL-3] Tierny J., Vandeborre J-P., Daoudi M., "Enhancing 3D Mesh Topological Skeletons with Discrete Contour Constrictions", The Visual Computer – International Journal of Computer Graphics, Springer Editions, volume 24, number 3, pp. 155-172, March 2008.

[LIFL-4] Tierny J., Vandeborre J-P., Daoudi M., "Partial 3D Shape Retrieval by Reeb Pattern Unfolding", Computer Graphics Forum - Eurographics Association - Ed. Blackwell, volume 28, number 1, pp. 41-55, March 2009.

[LIFL-5] Benhabiles H., Vandeborre J-P., Lavoué G., Daoudi M., "A comparative study of existing metrics for 3D-mesh segmentation evaluation", The Visual Computer – International Journal of Computer Graphics, Springer Editions, volume 26, number 12, pp. 1451-1466, December 2010.

[LIFL-6] Benhabiles H., Lavoué G., Vandeborre J-P., Daoudi M., "Learning boundary edges for 3D-mesh segmentation", Computer Graphics Forum - Eurographics Association - Ed. Blackwell, 2011, vol. 30, number 8, pp.2170-2182.

[LIFL-7] Drira H., Ben Amor B., Srivastava A., Daoudi M., Slama R., "3D Face Recognition under Expressions and Occlusions Pose Variations", accepted as regular paper in IEEE Transactions on Pattern Analysis and Machine Intelligence (to appear), 2013.

- *Personal bibliography for LIRIS partner (section 5.1.2)*

[LIRIS-1] Lavoué G, Dupont F, Baskurt A. A new CAD mesh segmentation method, based on curvature tensor analysis. Computer-Aided Design. 2005;37(10):975-987.

[LIRIS-2] Benhabiles H., Lavoué G., Vandeborre J-P., Daoudi M., "Learning boundary edges for 3D-mesh segmentation", Computer Graphics Forum - Eurographics Association - Ed. Blackwell, 2011;30(8), pp.2170-2182.

[LIRIS-3] Lavoué G. A local roughness measure for 3D meshes and its application to visual masking. ACM Transactions on Applied Perception (TAP). 2009;5(4).

[LIRIS-4] Lavoué G. Bag of Words and Local Spectral Descriptor for 3D Partial Shape Retrieval. Eurographics Workshop on 3D Object Retrieval. 2011.

[LIRIS-5] Revaud J, Lavoué G, Baskurt A. Improving Zernike Moments Comparison for Optimal Similarity and Rotation Angle Retrieval. IEEE Transactions on Pattern Analysis and Machine Intelligence. 2009;31(4).

[LIRIS-6] Barki H., Denis F., Dupont F. Contributing Vertices-Based Minkowski Sum of a Non-Convex--Convex Pair of Polyhedra, ACM Transactions on Graphics (TOG) 30(1):3:1-3:16, 2011.

[LIRIS-7] Barki H., Denis F., Dupont F.: Contributing vertices-based Minkowski sum computation of convex polyhedral, Computer Aided Design, Vol. 41, Issue 7, pp. 479-552, 2009.

- *Personal bibliography for LTCI partner (section 5.1.3)*

[LTCI-1-] Tierny J., Vandeborre J.P., Daoudi M. Enhancing 3D mesh topological skeletons with discrete contour constrictions. The Visual Computer, Vol 24, 2008.

[LTCI-2] Tierny J., Daniels J., Nonato L.G., Pascucci V., Silva C. Interactive quadrangulation with Reeb atlases and connectivity textures. Technical Report. Under revision for IEEE TVCG, 2010.

[LTCI-3] Tierny J., Daniels J., Nonato L.G., Pascucci V., Silva C. Inspired quadrangulation. Computer Aided Design (Proc. Of ACM SPM 2011), In press.

[LTCI-4] Mullen P., Memari P., de Goes F., Desbrun M. HOT : Hodge-optimized triangulations. ACM Transactions on Graphics (Proc. Of ACM SIGGRAPH), 2011.

[LTCI-5] Takayama, K., Schmidt R., Singh K., Igarashi T., Boubekeur T., Sorkine O., GeoBrush: Interactive mesh geometry cloning. Computer Graphics Forum (Proc. of Eurographics), Vol 30, pp. 1233-1240, 2011

[LTCI-6] Tierny J., Vandeborre J.P., Daoudi M., Partial 3D shape retrieval by Reeb pattern unfolding. Computer Graphics Forum, Vol 28, 2009.

[LTCI-7] Eitz M, Hildebrand K, Boubekeur T, Alexa M, Sketch-based image retrieval: benchmark and bag-of-features descriptors IEEE Transactions on Visualization and Computer Graphics, In press.

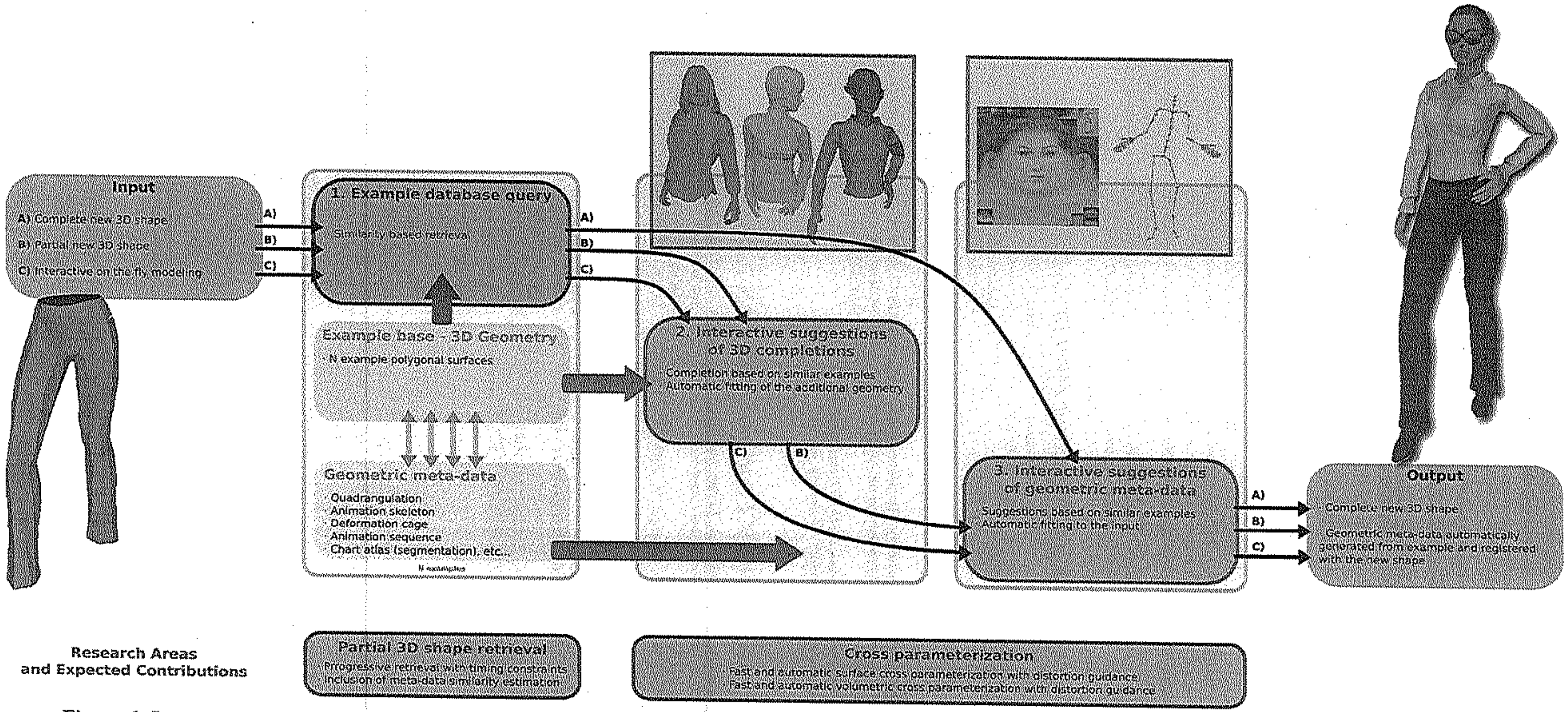


**Figure 6: Input-output diagram of our example-based 3D modeling support approach. Research areas and expected contributions appear in red at the bottom.**

## Annexe 2 – LISTES DES CONNAISSANCES PROPRES DES PARTIES NECESSAIRE A L'EXECUTION DU PROJET

**Pour LIFL/ Lille 1 :**

"Les connaissances antérieures de la PARTIE LIFL utilisées dans le cadre de ce projet sont essentiellement des méthodes et algorithmes de traitement géométrique, d'analyse, de segmentation, d'indexation et de reconnaissance de maillages 3D, ainsi que les codes sources associés.

Ces connaissances antérieures correspondent notamment aux publications citées ci-dessous :

--- CHAPITRES DE LIVRES ---
* Jean-Philippe Vandeborre, Hedi Tabia, Mohamed Daoudi "Reconnaissance et indexation 3D"
Chapitre de l'ouvrage "Vidéo 3D – Capture, Traitement et Diffusion", Laurent Lucas, Céline Loscos, Yannick Remion (editors), éditions Hermes Lavoisier, Traité IC2 Signal et Image, ISBN 9782746245457, septembre 2013.
* Stefano Berretti, Mohamed Daoudi, Alberto del Bimbo, Tarik Filali Ansary, Pietro Pala, Julien Tierny and Jean-Philippe Vandeborre "3D Object Indexing and Retrieval"
Chapitre de l'ouvrage "3D Object Processing: Indexing, Compression and Watermarking", Jean-Luc Dugelay, Atilla Baskurt, Mohamed Daoudi (editors), éditions John Wiley & Sons, ISBN 978-0-470-06542-6, avril 2008.

--- JOURNAUX INTERNATIONAUX ---
* Hedi Tabia, Mohamed Daoudi, Jean-Philippe Vandeborre and Olivier Colot "A parts-based approach for automatic 3D-shape categorization using belief functions"
ACM Transactions on Intelligent Systems and Technology (ACM TIST), volume 4, number 2, March 2013.
* Hedi Tabia, Mohamed Daoudi, Olivier Colot and Jean-Philippe Vandeborre "3D-object retrieval based on vector quantization of invariant descriptors"
SPIE Journal of Electronic Imaging, volume 21, issue 2, April - June 2012.
* Halim Benhabiles, Guillaume Lavoué, Jean-Philippe Vandeborre and Mohamed Daoudi "Learning boundary edges for 3D-mesh segmentation"
Computer Graphics Forum - Eurographics Association - Ed. Blackwell, volume 30, issue 8, pp. 2170-2182, December 2011.
* Hedi Tabia, Mohamed Daoudi, Jean-Philippe Vandeborre and Olivier Colot "A new 3D-matching method of non-rigid and partially similar models using curve analysis"
IEEE Transactions on Pattern Analysis and Machine Intelligence, volume 33, number 4, pp. 852-858, April 2011.
* Halim Benhabiles, Jean-Philippe Vandeborre, Guillaume Lavoué and Mohamed Daoudi "A comparative study of existing metrics for 3D-mesh segmentation evaluation"
The Visual Computer – International Journal of Computer Graphics, Springer Editions, volume 26, number 12, pp. 1451-1466, December 2010.
* Julien Tierny, Jean-Philippe Vandeborre, Mohamed Daoudi "Partial 3D Shape Retrieval by Reeb Pattern Unfolding"
Computer Graphics Forum - Eurographics Association - Ed. Blackwell, volume 28, number 1, pp. 41-55, March 2009.

* Julien Tierny, Jean-Philippe Vandeborre, Mohamed Daoudi "Enhancing 3D Mesh Topological Skeletons with Discrete Contour Constrictions"
The Visual Computer – International Journal of Computer Graphics, Springer Editions, volume 24, number 3, pp. 155-172, March 2008.
* Tarik Filali Ansary, Mohamed Daoudi, Jean-Philippe Vandeborre "A Bayesian 3D Search Engine using Adaptive Views Clustering"
IEEE Transactions on Multimedia, volume 9, number 1, pp. 78-88, January 2007.
* Tarik Filali Ansary, Jean-Philippe Vandeborre, Mohamed Daoudi "A framework for 3D CAD models retrieval from 2D images"
Annals of Telecommunications, special issue on "Technologies and tools for 3D imaging", November-December 2005, volume 60, n°11/12, pages 1337-1359.

--- CONFERENCES INTERNATIONALES ---
* Rachid El Khoury, Jean-Philippe Vandeborre, Mohamed Daoudi "3D-model retrieval using bag-of-features based on closed curves"
6th Eurographics Workshop on 3D Object Retrieval 2013 (co-event of Eurographics 2013), Girona, Spain, May 11, 2013.
* Guillaume Lavoué, Jean-Philippe Vandeborre, Halim Benhabiles, Mohamed Daoudi, Kai Huebner, Michela Mortara, Michela Spagnuolo
"SHREC'12 Track: 3D mesh segmentation"
5th Eurographics Workshop on 3D Object Retrieval 2012 (co-event of Eurographics 2012), Cagliari, Italy, May 13, 2012.
* Halim Benhabiles, Guillaume Lavoué, Jean-Philippe Vandeborre and Mohamed Daoudi "Kinematic skeleton extraction based on motion boundaries for 3D dynamic meshes"
5th Eurographics Workshop on 3D Object Retrieval 2012 (co-event of Eurographics 2012), Cagliari, Italy, May 13, 2012.
* Hedi Tabia, Mohamed Daoudi, Jean-Philippe Vandeborre, Olivier Colot "Non-rigid 3D shape classification using Bag-of-Feature techniques"
IEEE International Conference on Multimedia and Expo (ICME), Barcelona, Spain, July 11-15, 2011.
* Julien Tierny, Jean-Philippe Vandeborre, Mohamed Daoudi "Fast and precise kinematic skeleton extraction of 3D dynamic meshes"
19th IEEE International Conference on Pattern Recognition (ICPR 2008), Tampa, Florida, USA, December 8-11, 2008.
* Adrien Theetten, Tarik Filali Ansary, Jean-Philippe Vandeborre "3D-model view characterization using equilibrium planes"
4th International Symposium on 3D Data Processing, Visualization and Transmission (3DPVT'08), Atlanta, Georgia, USA, June 18-20, 2008.
* Julien Tierny, Jean-Philippe Vandeborre, Mohamed Daoudi "Topology driven 3D mesh hierarchical segmentation"
IEEE International Conference on Shape Modeling and Applications (Shape Modeling International 2007 – short paper), Lyon, France, June 13-15, 2007.
* Adrien Theetten, Jean-Philippe Vandeborre, Mohamed Daoudi "Determining Characteristic Views of a 3D Object by Visual Hulls and Hausdorff Distance"
5th IEEE International Conference on 3-D Digital Imaging and Modeling (3DIM 2005), Ottawa, Ontario (Canada), June 13-17, 2005.
* Jean-Philippe Vandeborre, Vincent Couillet, Mohamed Daoudi "A practical approach for 3D model indexing by combining local and global invariants"
1st IEEE International Symposium on 3D Data Processing Visualization Transmission (3DPVT'02), Padova, Italy, June 19-21, 2002."

**<u>Pour Télécom ParisTech / LTCI</u> :**

**- Ouvrage de références:**

1) "Topological methods in data analysis and visualization"
Valerio Pascucci, Xavier Tricoche, Hans Hagen and Julien Tierny (Editors)
Springer, 2010 (ISBN 978-3-642-15013-5).

**- Journaux Internationaux avec comité de lecture**

2) "Jacobians and Hessians of Mean Value Coordinates for Closed Triangular Meshes",
Jean-Marc Thiery, Julien Tierny, and Tamy Boubekeur
The Visual Computer Journal, 2013.

3) "Generalized Topological Simplification of Scalar Fields on Surfaces"
Julien Tierny and Valerio Pascucci
IEEE Transactions on Visualization and Computer Graphics.
Proc. of IEEE VIS 2012.

4) "Panorama Weaving: Fast and Flexible Seam Processing"
Brian Summa, Julien Tierny and Valerio Pascucci
ACM Transactions on Graphics.
Proc. of ACM SIGGRAPH 2012.

5) "CageR: Cage-based Reverse Engineering of Animated 3D Shapes"
Jean-Marc Thiery, Julien Tierny and Tamy Boubekeur
Computer Graphics Forum, 2012.
Presented at Eurographics 2013.

6) "Analytic Curve Skeletons for 3D Surface Modeling and Processing"
Jean-Marc Thiery, Bert Buchholz, Julien Tierny and Tamy Boubekeur
Computer Graphics Forum,
Proc. of Pacific Graphics 2012

7) "Inspired quadrangulation"
Julien Tierny, Joel Daniels II, Luis Gustavo Nonato, Valerio Pascucci and Claudio Silva
Computer Aided Design.
Proc. of ACM SPM 2011.

8) "Topology verification for isosurface extraction"
Tiago Etiene, Luis Gustavo Nonato, Carlos Scheidegger, Julien Tierny, Thomas Peters, Valerio Pascucci, Mike Kirby and Claudio Silva
IEEE Transactions on Visualization and Computer Graphics, 2012.
Presented at IEEE VIS 2011.

9) "Interactive quadrangulation with Reeb atlases and connectivity textures"
Julien Tierny, Joel Daniels II, Luis Gustavo Nonato, Valerio Pascucci and Claudio Silva
IEEE Transactions on Visualization and Computer Graphics, 2012.

10) "Interactive exploration and analysis of large scale simulations using topology-based data segmentation"
Peer-Timo Bremer, Gunther Weber, Julien Tierny, Valerio Pascucci, Marcus Day and John Bell
IEEE Transactions on Visualization and Computer Graphics, 2010.

11) "Loop surgery for volumetric meshes: Reeb graphs reduced to contour trees"
Julien Tierny, Attila Gyulassy, Eddie Simon and Valerio Pascucci
IEEE Transactions on Visualization and Computer Graphics, Vol 15, 2009.
Proc. of IEEE VIS 2009.

12) "Partial 3D shape retrieval by Reeb pattern unfolding"
Julien Tierny, Jean-Philippe Vandeborre and Mohamed Daoudi
Computer Graphics Forum, Vol 28, 2009.

**- Conférences Internationales avec comité de lecture**

13) "Scalable Seams for Gigapixel Panoramas"
Sujin Philip, Brian Summa, Julien Tierny, Peer-Timo Bremer, Valerio Pascucci
Proc. of Eurographics Symposium on Parallel Graphics and Visualization 2013.
Best Paper Award.

14) "Accurate and robust shape descriptors for the identification of rib cage structures in CT-images with Random Forests"
Mariem Gargouri, Julien Tierny, Erwan Jolivet, Philippe Petit, Elsa Angelini
Proc. of IEEE ISBI 2013.

15) "Quality Evaluation of 3D City Building Models with Automatic Error Diagnosis"
Jean-Christophe Michelin, Julien Tierny, Florence Tupin, Clement Mallet, and Nicolas Paparoditis
Proc. of ISPRS Conference on SSG 2013.

16) "Enabling advanced visualization tools in a web-based simulation monitoring system"
Emanuele Santos, Julien Tierny, Ayla Khan, Brad Grimm, Lauro Lins, Juliana Freire, Valerio Pascucci, Claudio Silva, Scott Klasky, Roselyne Barreto, Norbert Podhorszki
Proc. of IEEE eScience 2009.

**Pour LIRIS** :

Les connaissances antérieures de la Partie LIRIS utilisées dans le cadre de ce projet sont essentiellement:
- des algorithmes de traitement géométrique, d'analyse, de segmentation et d'indexation de maillages 3D ainsi que les codes source en langage C++ associés.
- le code source de la plateforme MEPP (http://liris.cnrs.fr/mepp/) développée au sein du LIRIS et

utilisée dans le cadre du projet, ainsi que l'expertise associée des membres du LIRIS.

Ces connaissances antérieures correspondent notamment aux publications citées ci-dessous :

Lavoué G, Dupont F, Baskurt A. A new CAD mesh segmentation method, based on curvature tensor analysis. Computer-Aided Design. 37(10):975-987. 2005.

Barki H., Denis F., Dupont F.: Contributing vertices-based Minkowski sum computation of convex polyhedral, Computer Aided Design, Vol. 41, Issue 7, pp. 479-552, 2009.

Revaud J, Lavoué G, Baskurt A. Improving Zernike Moments Comparison for Optimal Similarity and Rotation Angle Retrieval. IEEE Transactions on Pattern Analysis and Machine Intelligence. 31(4). 2009.

Lavoué G. A local roughness measure for 3D meshes and its application to visual masking. ACM Transactions on Applied Perception (TAP). 5(4). 2009.

Benhabiles H., Lavoué G., Vandeborre J-P., Daoudi M., "Learning boundary edges for 3D-mesh segmentation", Computer Graphics Forum. 30(8), pp.2170-2182. 2011.

Barki H., Denis F., Dupont F. Contributing Vertices-Based Minkowski Sum of a Non-Convex--Convex Pair of Polyhedra, ACM Transactions on Graphics (TOG) 30(1):3:1-3:16, 2011.

V. Vidal, C Wolf, F. Dupont. Robust feature line extraction on CAD triangular meshes. International Conference on Computer Graphics Theory and Applications, Algarve. 2011.

Lavoué, G. Combination of bag-of-words descriptors for robust partial shape retrieval. The Visual Computer. 28(9):931-942. 2012.

Lavoué, G., Tola, M., & Dupont, F. MEPP - 3D Mesh Processing Platform. In International Conference on Computer Graphics Theory and Applications. 2012.

V. Vidal, C Wolf, F. Dupont. Combinatorial Mesh Optimization. The Visual Computer 28(5):511-525. 2012.

V. Vidal, C Wolf, F. Dupont. Mesh Segmentation and Global 3D Model Extraction. Symposium on Geometry Processing, Tallinn, Estonia. 2012

R. Arcila, C. Cagniart, F. Hétroy, E. Boyer, F. Dupont. Segmentation of temporal mesh sequences into rigidly moving components. Graphical Models 75(1):10-22 2013.

- Capanna C, Gesquière G, Jorda L, Lamy P, Vibert D, "Three-dimensional reconstruction using multiresolution photoclinometry by deformation", The Visual Computer, International Journal of Computer Graphics 2013, Volume 29, Issue 6-8, pp 825-835, ISSN 0178-2789, DOI 10.1007/s00371-013-0821-5, avril 2013

- Bénière R; Subsol G, Gesquière G, Le Breton F, Puech W, "A Comprehensive Process of Reverse Engineering from 3D Meshes to CAD Models", Computer Aided Design, Vol. 45, No 11, p. 1382-1393, November 2013

- Bénière R, Subsol G, Gesquière G, Le Breton F, Puech G, « Topology Reconstruction for B-Rep Modeling from 3D Mesh in Reverse Engineering Applications », SPIE, San Francisco, 01/2012

- Mignard C., Gesquière G., Nicolle C., "Interoperability between GIS and BIM", International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, KMIS 2011, October 26-29, 2011, Paris, France, pp 359-362

- Bénière R, Subsol G, Gesquière G, Lebreton F, Puech W, « Decomposition of a 3D triangular mesh into quadrangulated patches », International Conference on Computer Graphics Theory and Applications (GRAPP 2010), Angers.

- Bénière.R, Subsol G., Gesquière G., Le Breton F., Puech W., « Recovering Primitives in 3D CAD meshes », SPIE, San Francisco, 01/2011.

<u>Pour Gamagora</u> :

- Modèles 3D mis à disposition par Gamagora.

<u>Pour 3DDUO</u> :

- la base de modèles 3D fournie
- la plateforme de création de jeux Casual Crossing Engine

## Annexe 3 – COMPOSITION DU COMITE

**LIFL/LILLE 1**

Monsieur :
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**3DDUO**

**Maxence Devoghelaere**
PDG
La Plaine Images / L'Imaginarium
Bureau 204
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## Annexe 4 – LISTE DES AFFILIES

[À compléter si applicable]

## Annexe 5 – ANNEXE FINANCIERE / BUDGET DU CONSORTIUM

| NOM de PARTENAIRES | N° de la convention/décision d'aide ANR | Montant prévisionnel HT de la subvention ANR | Montant prévisionnel HT des dépenses pour le PROJET |
|---|---|---|---|
| LILLE 1 (LIFL) | ANR-13-CORD-0013-01 | 138.320 € | 523.265€ |
| CNRS (LIRIS) | ANR-13-CORD-0013-02 | 107.617€ | 582.020€ |
| Télécom ParisTech | ANR-13-CORD-0013-03 | 153105 € | 513.695€ |
| LYON 2 (GAMAGORA) | ANR-13-CORD-0013-04 | 45.760€ | 262.360€ |
| 3DDUO | ANR-13-CORD-0013-05 | 60.191 € | 133.757€ |
| Total | | 504.993 € | 2.051.097€ |