Liste des sujets MFEs proposés pour l'année 2019-2020

LISA (Laboratories of Image Synthesis and Analysis)

1/ Prise d'images panoramiques 360° de lieux fréquentés

Les images à 360° permettent de reconstruire un environnement d'immersion, à partir d'une série de photographies prise de manière centrée et présentant un chevauchement suffisant. Cependant, l'acquisitions d'un lieu fortement fréquenté reste un défi, dû notamment aux différents éléments mobiles dans la scène (personnes, voitures, oiseaux, etc). Des méthodes classiques de suppression d'avant-plan existent (voir foreground substraction methods) mais demandent plusieurs acquisitions à une position fixe. De plus, avec ces méthodes, un élément de l'avant plan suffisamment présent et statique dans le champ de vue sera catégorisé comme appartenant à l'arrière-plan (pour exemple: personnes qui s'arrêtent temporairement sur une place, voitures à l'arrêt). Pour constituer l'image panoramique 360°, un système Pan/Tilt (Panocatcher Maestro 4 HD) permet d'automatiser les acquisitions photographiques nécessaires (positionnements angulaires et déclenchements de l'appareil photographique) en fonction du chevauchement nécessaire. Les objectifs de ce travail sont:

- De développer un outil pour reconstruire les images panoramiques, supprimant les éléments parasites de l'avant-plan et permettant des manipulations de bases (définition du centre, paramétrisation du stitching,…) ;
- D'identifier les zones de l'arrière-plan manquantes par la détection des objets masquant ces zones (voir faster RCNN, YOLO);
- D'interfacer l'outil d'acquisition afin d'acquérir les photographies nécessaires à la reconstruction d'images panoramiques et de compléter ceux-ci pour couvrir les zones manquantes (notamment dû à la présence d'objets mobiles) ;
- D'optimiser la prise de photographies pour couvrir les besoins.

Le travail comprendra également un état de l'art générale et comparé sur l'ensemble du sujet.

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2/ Virtual 3D crime scene interactive analysis

In collaboration with forensic specialist, the project will consist in developing a web application (restful) combining 3D point cloud, and forensic expertise documents. The application is meant to be used by student in criminology, several aspects such as time critical path, expertise order and simulated costs are to be encoded in a global framework.

The project will also involve a thorough analysis of the needs and the constraints related to this project (storage/bandwidth/computer CPU client and server side/...).

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3/ CT/MRI to Ultrasound style transfer

Ultrasound imagining signal synthesized from a 3D data volume and the 6 dof position of a probe with respect to a deformable phantom. The general idea is to produce US data from MRI or CT volume of the region of interest. Several techniques can be tested, from the physic simulation to the deep learning style transfer.

The probe is developed by an other master thesis.

ref: [1] Anila Satheesh B.,Arun K.Thittai.A fast method for simulating ultrasound image from patient-specific CT data.Biomedical Signal Processing and Control Volume 48, February 2019, Pages 61-68 [2] Xin Y et al. Generative Adversarial Network in Medical Imaging: A Review.arXiv:1809.07294v2

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4/ ULB audiences' occupancy monitoring

The University is currently facing a logistical problem in terms of audiences' attendance; the number of students enrolled has increased more than the rate of available rooms, resulting in overcrowding in some audiences. Indeed, the space allocation for the first semester is based on a very approximate number of students attending the courses, and this is even more valid since some students sometimes enrol relatively late. In addition, a profound reflection is underway within the University on the size of future audiences to be built; for example, an audience of 900 seats is indeed being built in the Erasme Campus, but the interest of such large audiences is only undeniable for first or second year students from Solvay or Ecole Polytechnique, although more and more courses are podcasted and broadcasted online.

In this context, the objective of this master's thesis is to design a system based on a camera connected to a raspberry pi determining the audiences' occupancy (i.e. the actual number of students present in an audience and effectively following the course). The University authorities will then use this information to draw conclusions for the following years, or even make readjustments during the second semester. In order to respect privacy laws, the recognition algorithm based on e.g YOLO will run on the raspberry pi so that only the number of students will be repatriated via the SmartCampus infrastructure, and not the images.

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5/ View synthesis-based 3D viewer / Visionneur d'objets 3D basé sur une synthèse de vues

Le but du projet est de développer un visionneur WebGL d'objets 3D (navigation autour de l'objet, zoom, translation modérée) basé sur un sous-échantillon de prises de vue de l'objet et d'un synthèse de vue (interpolation) pour générer les points de vue inexistants. La synthèse de vue se basera sur les développements existants du laboratoire LISA, complétées pars des approches spécifiques. Le projet abordera notamment trois aspects :

- La gestion des chargements : une gestion des données (la sélection, la disposition et la définition du nombre de vues en fonction de la spécificité de l'objet (concavité, complexité,…), une approche en niveaux de détails ou multi-résolution… ;
- La qualité (complexité, résolution, précision…) du modèle sous-jacent, nécessaire à la génération des cartes de profondeurs utilisés par la synthèse de vues ;
- Une comparaison objective (temps de calcul, quantité de données…) et subjective (qualité visuelle) par rapport aux solutions existantes (mesh, pointcloud…). Le problème sera abordé tout d'abord de manière virtuelle sur base d'un modèle 3D existant et ensuite par une acquisition réelle d'un objet à définir.

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6/ Deep Learning for artifact segmentation in whole histological slide images

During the manipulation and acquisition process to produce digital slides, many artifacts can be produced. Artifacts can interfer with the correct analysis of the slide by automated methods. They can have lots of different shapes and sizes, which make their detection by standard image processing technique very difficult. The goal of this project is to use Deep Learning methods to segment the artifacts in whole-slide images.

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7/ 6 DoF phantom tracker for an ultrasound exam simulator

Development of a device that mimics a physical ultrasound imagining exam, the probe being a dummy probe, the ultrasound imagining signal is to be synthesized from a 3D data volume and the 6 dof position of the probe with respect to a deformable phantom.

The synthesis part is done by an other master thesis.

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8/ Defining optimized SPECT reconstruction parameters for liver functionality quantification with MIM Software

Single-photon emission computed tomography (SPECT) is a nuclear medicine tomographic imaging technique using gamma rays.

The technique requires delivery of a gamma-emitting radiopharmaceutical into the patient, normally through injection into the bloodstream. The pharmacokinetic of the radiopharmaceutical in an organ allows studying the biology or the functionality of the considered organ. The pharmacokinetic is obtained by image quantification of the administered radiopharmaceutical. The perfusion and the functionality of the liver are evaluated trough the administration of respectively 99mTc-MAA and 99mTc-BRIDA.

SPECT imaging is performed by using a gamma camera to acquire multiple 2-D mages (also called projections), from multiple angles. Software is then used to apply a tomographic reconstruction algorithm to the multiple projections, yielding a 3-D data set. Tomographic reconstruction algorithm requires parameter definition and tandardization to allow reproducible quantification.

The aim of the master thesis is to define optimized SPECT reconstruction for liver functionality quantification with MIM Software after 99mTc-MAA or 99mTc-BRIDA administration.

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9/ 3DVS : View Synthesis-based 3D viewer / Visionneur d'objets 3D basé sur une Synthèse de Vues

Le but du projet est de développer un visionneur WebGL d'objets 3D (navigation autour de l'objet, zoom, translation modérée) basé sur un sous-échantillon de prises de vue de l'objet et d'une synthèse de vue (interpolation) pour générer les points de vue inexistants. La synthèse de vue se basera sur les développements existants du laboratoire LISA, complétés par des approches spécifiques. Le projet abordera notamment trois aspects :

• La gestion des chargements : une gestion des données (la sélection, la disposition et la définition du nombre de vues en fonction de la spécificité de l'objet (concavité, complexité,…), une approche en niveaux de détails ou multi-résolution… ;

• La qualité (complexité, résolution, précision…) du modèle sous-jacent, nécessaire à la génération des cartes de profondeurs utilisées par la synthèse de vues ;

• Une comparaison objective (temps de calcul, quantité de données…) et subjective (qualité visuelle) par rapport aux solutions existantes (mesh, pointcloud…). Le problème sera abordé tout d'abord de manière virtuelle sur base d'un modèle 3D existant et ensuite par une acquisition réelle d'un objet à définir.

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10/ Reti Slides: Real-Time Structured Light Depth Sensing

An increasing number of 3D VR/AR applications rely on the estimation of a depth map, i.e. each pixel of the RGB image is associated to an accurately sensed depth value. In previous years, we have developed and characterized a high-resolution structured light depth sensing device. This Master thesis aims at further developing a stand-alone prototype, automating the full process, including the calibration, triggering and image post-processing, ported to an embedded device. Moreover, the algorithm should be parallelized and CUDA accelerated to reach real-time video performance.

Student profile :

The student should combine software programming and hardware DIY skills, be familiar with Linux and show interest in 3D acquisition.

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11/ Alarms: Automatic Laparoscopic 3D Reconstruction in Medical Surgery

This thesis aims at reconstructing the surface of organs in the abdomen using structure from motion on monocular laparoscopic sequences. Such photogrammetric 3D reconstructions have already been applied successfully on rigid bodies (e.g. architectural structures) with many software packages (commercial and open source) that have been developed the last decade. Literature suggests that similar processes can also be applied to soft tissue, e.g. in the reconstruction of the liver surface. The thesis student will start from these studies and further develop techniques to make the system as robust as possible to various test cases.

Student profile:

Good programming skills and interest in 3D medical data.

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12/ AI2HO2-Transform: Transforming an Array of Images (AI) into (2) Hologram Hogels (HO^2)

Digital holograms can be produced by capturing pictures from the scene/subject with a camera moving mm by mm along a rail (i.e. the Array of Images) and rearranging the pixels of these images to create the Hogels, which are the equivalent of the pixels in a Hologram. The project aims at implementing this pixels-to-Hogels transform and related post-processing for any camera setting based on the mathematical formulas available from literature. In order to validate the process, the projections of a 3D Blender scene are AI2HO2-transformed with visualization of the so-obtained hologram within the OpenHolo.org simulation framework. Since giga-pixels are involved in the transformation and rendering processes, software optimizations (memory caching, parallelization, …) should be applied in specific modules of the processing chain.

Student profile :
Good programming skills and interest in digital holography.
Promotor & contact :

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13/ Linking gene expression and tissue morphology with deep learning

Spatial transcriptomics makes it possible to determine the full transcriptome, that this, the expression of all messanger RNAs of cells, at defined spatial location in tissue sections. This revolutionary technology effectively unites the century-old tradition of tissue section observation under the microscope with XXI st century genomics. We are now poised to understand the biological processes that generate the microscopic morphologies that define organs in health and disease. Indeed, most biological functions and tissue states can be inferred from transcriptomic profiles.

While transcriptomic data analysis has yield major discoveries in the last two decade, apprehending it in the context of space and tissue morphology is completely new. Moreover, how to characterize quantitatively tissue morphology is also an open topic with implication for both fundamental research and diagnostic. The thesis will address both problems in the context of cancer research.

First, using deep learning auto-encoders thousands of images patches will be clustered in a low dimension latent space that abstracts-out irrelevant noise and features such as tissue orientation, etc. Second, another deep network will be trained to associate these latent space representations with the corresponding transcriptomic profiles. This interdisciplinary work will be supervised by researchers from LISA (image analysis) and IRIBHM (bioinformatics and oncology, project initiator).

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14/ Interactive segmentation of cancer tissue images

Malignant tumors are made of multiple types of cells and heterogeneous morphological structures. This intra-tumoral heterogeneity is key to understand cancer progression and the anti-tumoral immune response. The various morphological structures present within a tumor are readily visible under the microscope. Yet their characterization is currently resting on visual inspection, which is subjective, qualitative and time-consuming. A tool to interactively assist doctors and researchers segmentation and labeling of morphological structures within tumors microscope images would be extremely useful. It would also be a step towards ‘digital pathology’, the automated diagnostic of diseases from the images of sick tissues.

Specific morphological structures have distinctive textures that could exploitable for interactive machine learning and a dramatic speed up of tissues segmentation task (see figure).

The purpose of the thesis is to develop a prototype of computer-assisted tissue segmentation, and demonstrate how its application to a collection of cancer tissues yield quantitative insights on tumor morphology not accessible otherwise. This interdisciplinary work will be supervised by researchers from LISA (image analysis), IRIBHM (bioinformatics and oncology, project initiator) and the pathology department of the Bordet Institute).

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15/ Extraction automatique du profil d'une poterie pour le calcul de son volume et génération du modèle 3D

Un site web, http://capacity.ulb.ac.be, permet actuellement aux archéologues de calculer le volume d'un récipient à partir de son profil. Dans certains cas, l'extraction automatique du profil intérieur permettant le calcul du volume ne fonctionne pas. L'objectif principal de ce mémoire sera d'implémenter un nouvel algorithme permettant d'extraire l'axe et le profil intérieur très rapidement mais également le profil extérieur afin de générer un modèle 3D visible dans un viewer web 3D et exportable en fichier stl (par exemple, utilisable pour l'impression 3D). En outre, dans le cadre d'un stage d'étudiant, une refonte du site dans un CMS wordpress est en cours de réalisation. Le second objectif de ce mémoire sera de finaliser ce site et d'incorporer les fonctionnalités ci-dessus afin qu'un nouveau site parfaitement fonctionnel soit mis en ligne en 2019.

Prérequis : Analyse d'image, python/C++, html5 (js, ...)

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16/ Deep in vitro cell tracking

Development of a deep learning based technique for in vitro cell tracking (phase contrast microscopy)

Recent development in image segmentation enable very complex image segmentation, with ill defined borders such those observed for in vitro cell culture.

The project aims is to adapt these techniques in the context of image sequence analysis and to compare performance with more classical approaches.

Pre requisite : image processing, python, tensorflow

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17/ Machine learning on Next-Generation Sequencing (NGS) data

The aim of this Master thesis is to develop data analysis and machine learning methods able to establish DNA sample quality from a genomic dataset obtained by NGS. The NGS technology optimizes the molecular characterization of tumors which is essential to determine the most appropriate treatment for each patient ("personalized medicine"). The determination of the quality of the analyzed samples, sometimes very small (biopsies), is very important for the proper use of the information provided by NGS. This work will be done in close collaboration with the Molecular Biology unit of the Pathology Department of the ULB Erasme hospital.

Prerequisite:Basics of machine learning/data classification, programming (python or R)

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17/ AI based industrial automation: advanced sorting without human intervention

Context Industrial processes can be hazardous or dangerous and often menial. And where human intervention is both risky and/or costly, automation could be indispensable. Sorting is an industry process which is already strongly automated with applications in e.g. waste processing, food sector, …

Typically vision is used to detect and identify objects. Current state-of-the-use algorithms typically employ little to no artificial intelligence, and the resulting performance is suboptimal: often human operators are required at the end of the line to sort what was not correctly classified.

Objective The goal of this thesis is to explore the possibilities, relevance and impact of artificial intelligence in sorting applications. You will build a simple lab hardware setup : camera(s) overlooking a stationary bin of objects which need to be sorted into other bins. Algorithms need to be selected/developed to identify the (result of the) sorting actions of the human operator: which items have been moved from the initial bin to another bin, which items were left in the initial bin.

The focus point of this thesis is to explore the possibilities of artificial intelligence : a model needs to be trained by observing the actions of human operator. Its ultimate goal is to reproduce the sorting logic of the operator. Based on camera images the model needs to detect and classify items like the operator would, so that the sorting could be automated.

The automation of the sorting action itself (grabbing and moving objects) is beyond the scope of this thesis.

Through this thesis, you will highlight the opportunities, challenges and pit-falls in the modeling and the training phases for sorting applications.

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18/ Real-time bicycles tracking on ULB campus

Mobility has become a major social issue. Indeed, it guarantees the accessibility, attractiveness and quality of exchanges but it also generates many costs: financial costs (development and infrastructure) as well as social and environmental costs - lost time, degraded quality of life, noise, air pollution or greenhouse gas emissions. Therefore, the University's Environment and Mobility Department is currently working on a sustainable mobility policy to promote alternatives to the use of private car, including through the development of campus public spaces for cyclists.

In this context, the objective of this master's thesis is to design a camera device connected to a raspberry pi tracking bicycles in real-time on ULB campus in order to extract information like the number of in/out bikes per hour or the number of parked bikes in a zone. The tracking algorithm based on e.g. YOLO will run on the raspberry pi so that only the counted values will be sent in real-time via the SmartCampus infrastructure, and not the images.

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