



Enabling X-ray CT based industry 4.0 process chains by training next generation research experts - "xCTing"

Is Hiring

15 ESRs
Early Stage Researchers

<https://xcting-itn.eu/jobs/>

Eligibility Criteria

- Hold a Master's degree
- In the first four years (full-time equivalent research experience) of research careers
- Have not yet been awarded a doctoral degree
- The Master's degree must be excellent and in the discipline that is relevant to the ESR project that you are applying for.
- Must not have resided or carried out your main activity (work, studies, etc.) in the country of the host organisation for more than 12 months in the 3 years immediately prior to your recruitment.
- Proficiency in English is required, as well as good communication skills, both oral and written. Successful candidates may need to provide an English test (e.g. IELTS, TOEFL, Cambridge English). You may be exempt if you are a national of a majority native-English speaking country, or have qualifications / degree that has been taught and assessed in English.

How to apply

- Before submitting your application, make sure you are eligible to apply.
- Visit the xCTing job site and provide the following information:
 1. Your motivation letter
 2. CV
 3. Certificates of education (official transcripts in English)
 4. Other relevant information (skills, publications etc.) if available
 5. Recommendation letters if available
 6. English language proficiency test results if available

Apply before
20 June 2021

ESR host

RWTH Aachen - WZL

Campus-Boulevard 30
 Aachen, 52074
 Germany



RWTH AACHEN
 UNIVERSITY

Vacancy ESR01

Germany

Autonomous adaption of CT acquisition parameters

CT acquisition geometries in collaboration with ESRs 9-12;

- PhD dissertation.

Objectives

Develop a model to automatically optimize exposure parameters to reduce dimensional measurement uncertainty and increase defect detection probability. In function of dimensional measurement uncertainty, defect detection probability and region of interest, the model will determine the optimal combination of tube voltage, tube current, exposure time per projection, workpiece orientation for conventional CT (computed tomography) scanning geometries, and then expand the work towards non-conventional fast and adaptive CT scanning geometries to fit in with the work performed by other researchers in the project. The initial model will be developed based on simulated data, and then validated in experimental conditions using calibrated workpieces.

Credibility

RWTH has extensive prior experience with modelling CT acquisition parameters. Using state-of-the-art simulation and image processing techniques, it is considered feasible to not only include the full set of available exposure parameters (incl. the scanning geometry) in a single model, but to do this in a task-specific manner.

Planned secondments

- Volume Graphics GmbH: in-depth study of end-user requirements and working procedures;
- Fraunhofer Institute for Integrated Circuits IIS: collaborate with ESR5 on integrating the digital twin into optimal acquisition parameter definition.

Expected results

- Validated model to determine the optimal set of exposure parameters that can be applied to any given work piece, including for nonconventional

2D neural networks for artefact correction during CT reconstruction

Objectives

Development of deep learning-based reconstruction algorithms for eliminating CT(computed tomography) artefacts at the level of the radiographs. Through simulation, a large heterogeneous set of radiographic data with and without the presence of features that lead to reconstruction artefacts will be generated (e.g. with or without scatter, monochromatic vs polychromatic X-rays, ...). This dataset will be used for training and validating convolutional neural networks using the artefact-free condition as expected output. It is envisaged that separate networks will be designed for each type of artefact.

Expected results

- Demonstrator software for deep learning-based elimination of CT artefacts;
- Validation of the method on academic parts as well as on an industrially relevant case study;

- Joint publications with the other ESRs working in WP1 (autonomy) as well as with other ESRs (applications);
- Validation of the methods on academic parts as well as on an industrially relevant case study;
- PhD dissertation.

Credibility

Exploratory research at KUL and other research groups has shown great potential for novel neural network architectures to be applied for artefact correction in CT. Using simulation, it is possible to yield a large set of training data with perfect labelling (i.e. realistic vs artefact-free).

Planned secondments

- Volume Graphics GmbH: in-depth study of end-user requirements and working procedures;
- Centrum Wiskunde & Informatica: collaborate with ESR12 linking autonomous scanning (ESR12) and autonomous reconstruction (ESR2). Collaborate with ESR3 linking 2D-CNN (convolutional neural network)- and 3D-CNN-based artefact correction.

KU LEUVEN



Vacancy ESR02

Belgium

ESR host

KU Leuven - PSI

Kasteelpark Arenberg 10 - bus 2441
Leuven, 3001
Belgium

ESR host

Leiden University

Niels Bohrweg 1
 Leiden, 2333 CA
 Netherlands



Vacancy ESR03 Netherlands



**3D neural networks for
 artefact correction during
 CT reconstruction**

Objectives

Development of deep learning-based reconstruction algorithms for eliminating CT(computed tomography) artefacts at the level of the reconstructed data. Data generation for training and validation of the 3D neural networks will be running in parallel with that of ESR2 due to the large computational workload. Radiographic simulations will be reconstructed using the ASTRA toolbox and 3D neural networks will be applied to the reconstructed data, using corresponding artefact-free data as expected output. Further testing of the efficacy of the trained networks will be performed by evaluating their effect on dimensional measurement accuracy and defect detection. Furthermore, the networks will be trained separately on data that was corrected using the 2D CNN (convolutional neural network) approach developed by ESR2, which is expected to yield a more robust outcome.

Expected results

- Demonstrator software for deep

learning-based elimination of CT artefacts;

- Validation of the method on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in autonomy as well as with other ESRs (applications);
- Combination with the artefact reduction approach used by ESR2;
- PhD dissertation.

Credibility

The dual approach of 2D and 3D neural networks is expected to result in superior artefact correction compared with current methods, and can be applied in practice with a very high data throughput (e.g. a few milliseconds per radiograph for applying a trained 2D CNN, and a few seconds for applying a trained 3D CNN to new reconstruction data)

Planned secondments

- KU Leuven: collaborate with ESR2 linking 2D-CNN- and 3D-CNN-based artefact correction;
- Waygate Technologies: industrial experience, industrial application of research and collaboration with ESR10 towards enhanced optimization of scan quality.

Smart and autonomous feature detection and quantification for ensemble datasets and single ensemble members

Objectives

Develop and implement feature detection and quantification techniques coupled with visual analysis to investigate and explore the continuously generated inspection data of entire ensemble datasets as well as single ensemble members. Regarding single ensemble member analysis, techniques will centre around detection and quantification of defects and features. For this purpose, smart and autonomous segmentation and defect/feature detection and quantification algorithms will be developed, which (aside conventional techniques) will make strong use of deep learning. Regarding ensemble analysis, comparative visualization techniques will be developed to analyse large dataset ensembles at once. The generated quantitative ensemble results will be used for production trend-monitoring in order to predict and investigate production fluctuations as well as drifts..

Expected results

- Dedicated feature detection and quantification techniques to analyse and visualize ensemble datasets as well as single ensemble members;
- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in WP2 (autonomy) as well as with other ESRs (applications);
- PhD dissertation.

Credibility

Recent developments in automated defect recognition using novel image processing techniques (incl. new architectures and optimizers for deep learning networks) have shown incredible performance on reference datasets in terms of both classification and segmentation.

Planned secondments

- Volume Graphics GmbH: algorithm speed-ups and software integration.
- Testia GmbH: collaborate with industrial NDT service provider, apply automated feature detection to cases from aerospace industry.
- TU Wien: fulfil PhD regulations.



Vacancy ESR04

Austria



ESR host

University of Applied Sciences
Upper Austria

Stelzhamerstraße 23
Wels, 4600
Austria

ESR host

Fraunhofer Institute for
 Integrated Circuits IIS

Am Wolfsmantel 33
 Erlangen, 91058
 Germany



Vacancy ESR05 Germany

Digital twin for CT analysis chains

Objectives

Production monitoring using computed tomography (CT) is increasingly used in casting industry. The work from this task will be very valuable when new processes are installed in the factory. The optimization of the image processing parameters has to be done before first parts are casted to decrease the process startup time. The generated parameters can be optimized offline without stopping the process and then can be distributed to every machine in the production.

Another aspect is that due to the consequences of Industry 4.0 the lot size of castings to be produced of the same type will decrease more and more to lot size one. This work will also address new production techniques like additive manufacturing (AM) where lot size one is a normal approach. In these cases, optimizing the image processing parameters needs to be done without real CT data sets of casting parts.

Expected results

- Software for determining image

processing parameters based on simulation data;

- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in autonomy as well as with other ESRs (applications);
- PhD dissertation.

Credibility

Use of digital twins has proven to be highly beneficial, including but not limited to conventional metrology techniques and medical CT. The current task focuses on image processing.

Planned secondments

- FHOOE: exchange of defect detection knowledge and experience; collaborate with ESR7 on autonomous defect detection;
- Waygate Technologies: integrating the digital twin into optimal scanning trajectory definition;
- RWTH Aachen University: validation of methods on academic workpieces; academic experience, including teaching training; regulatory PhD trainings.

Determination of task-specific measurement uncertainty caused by geometrical misalignments

Objectives

Use a Monte Carlo approach to simulate misaligned projections and subsequent back-projection of individual CAD-model surface points, which are subsequently recombined to point clouds for corresponding surface fitting. The approach is fundamentally different from state-of-the-art Monte-Carlo-based virtual metrology computed tomography (CT) approaches, which necessitate running a complete xCT metrology chain for each individual combination of influence factor values. Whereas the latter is already computationally demanding for a single simulation run, combining these steps in a full Monte Carlo approach is computationally excessive and impossible for in-line lot-size-one applications. The proposed method will, therefore, fully limit the Monte Carlo approach to coordinate space by avoiding the time-consuming volumetric reconstruction and segmentation steps, hence allowing uncertainty determination in seconds.

Expected results

- Fast Monte-Carlo tool to assess geometric misalignment related uncertainties;
- Holistic and fast task-specific uncertainty determination tool;
- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in metrology as well as with other ESRs (applications);
- PhD dissertation.

Credibility

Host institution's research group has extensive experience in industrial CT geometry characterization, incl. the characterization and correction of misalignment. Modelling the effect of misalignment on measurement uncertainty is a logical next step in this line of research.

Planned secondments

- Accent Pro 2000
- University of Padova
- University of Applied Sciences Upper Austria (FHOOE)

KU LEUVEN



Vacancy ESR06

Belgium

ESR host

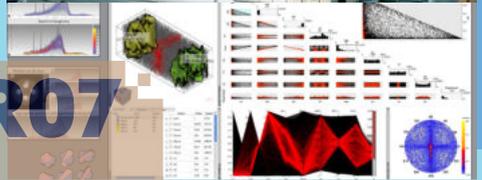
KU Leuven - MaPS

Celestijnenlaan 300, bus 2420
Leuven, 3001
Belgium

ESR host

University of Applied
 Sciences Upper Austria

Stelzhammerstraße 23
 Wels, 4600
 Austria



Filled

Vacancy ESR07

Austria



Determination of task-specific measurement uncertainty caused by physical effects

Objectives

Holistic and fast task-specific uncertainty determination (in collaboration with ESR 6). ESR7 focusses on the physical effect related uncertainties (X-ray tube model: spectrum and focal spot shape and size; Noise: electronic and photon; Detector model: detection efficiency and detector inherent scatter). For each parameter connected to one or more physical effects, realistic ranges will be determined through a combination of literature review and experimental measurements on CT(computed tomography) systems available throughout the consortium. Next, the effect of each parameter on measurement uncertainty will be modelled, and a combinatory regression model will be derived.

Expected results

- Development of an in-line CT simulation tool;

- Sensitivity analysis and visualization of individual influence factors;
- Holistic and fast task-specific uncertainty determination and visualization (with ESR6);
- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in WP2 (metrology) as well as with other ESRs (applications);
- PhD dissertation.

Credibility

High degree of correlation is expected between physical effects and measurement uncertainty.

Planned secondments

- TU Wien: fulfil PhD regulations and benefit from academic feedback on fast and efficient image processing.
- KU Leuven: collaborate with ESR6 (and ESR8 simultaneously at KU Leuven for secondment) linking autonomous verification to holistic uncertainty determination method, and preparing intercomparison.

Enabling Industry 4.0 by fast and accurate CT metrology

Objectives

Development of methods for fast and autonomous in-scanning characterization, verification and condition monitoring of in-line computed tomography (CT) systems, as well as of the main components of the system itself. Development of advanced methods for ensuring traceability of in-line CT scanning. This approach will make optimal use of the data generated during in-line CT scanning, going beyond its intended use for 3D reconstruction to characterize the performance of the equipment itself. This includes real-time geometrical error estimation, X-ray spectrum and focal spot analysis, detector efficiency and scatter estimation.

Expected results

- Methods and reference objects for fast and autonomous CT metrology testing and for traceability establishment;
- Validation of the methods on industrial equipment;

- Joint publications with the other ESRs;
- PhD dissertation

Credibility

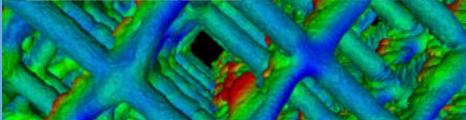
The Research Group has extensive experience and world-class reputation in precision manufacturing, industrial metrology and innovative CT. The University of Padova is one of Europe's oldest and most prestigious seats of learning, and is ranked first among leading Italian universities for quality of research.

Planned secondments

- Waygate Technologies: industrial experience, industrial application of research and collaboration with ESR 2 towards enhanced optimization of scan quality;
- Nuovo Pignone International Ltd.: case study of industrial implementation;
- KU Leuven: collaborate with ESR6 (and ESR7 simultaneously at KUL for secondment) linking autonomous verification to holistic uncertainty determination method. Preparing intercomparison in collaboration with ESR6 and ESR7.

Vacancy ESR08

Italy



ESR host

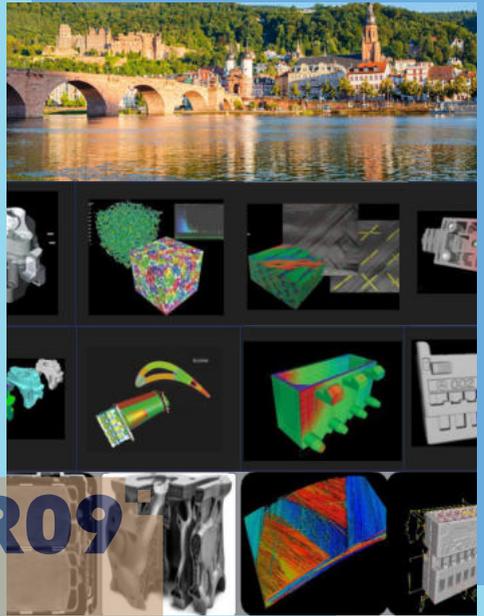
University of Padova

Padova, 35123
via VIII Febbraio, 2
Italy

ESR host

Volume Graphics GmbH

Wieblinger weg 92A
 Heidelberg, 69123
 Germany



Vacancy ESR09 Germany

A-priori-knowledge enhanced CT reconstruction for fast, optimized scanning strategies

Objectives

To enable fast in-line computed tomography (CT) - scanning by reducing the number of projections required while maintaining a good signal-to-noise ratio (SNR); to exploit a priori data to enhance the quality and reduce CT artefacts in CT reconstructions, especially in case of multi-material workpieces. Starting from representative high-quality scans of different object classes, the number of projections will be incrementally reduced, and parallel approaches towards sparse-projection reconstruction will be applied, one of which makes use of the a priori information available of the object.

Expected results

- Demonstrator software of a novel CT system independent in-line reconstruction method that exploits a priori information to deliver high quality data with good SNR and

limited CT artefacts out of few projections;

- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in autonomy as well as with other ESRs (applications);
- PhD dissertation.

Credibility

Earlier work (incl. but not limited to the medical field: iterative reconstruction techniques used on commercial medical CT scanners from each manufacturer) has shown the potential of sparse-projection and/or model-based reconstruction. While it is challenging to yield adequate reconstruction results within a reasonable computational time, the use of state-of-the-art graphics processing unit (GPU)-based reconstruction makes this feasible.

Planned secondments

- KU Leuven: validation of methods on academic work pieces; academic experience, PhD trainings.
- Fraunhofer Institute for Integrated Circuits IIS: validation on IIS in-line systems. Collaborate with ESR4.

Determination of optimal scanning trajectories and related parameters

Objectives

To derive optimal and flexible scanning trajectories by exploiting a priori knowledge in order to enable fast in-line computed tomography (CT) - scanning. The ESR will use prior information from CAD models to determine under which angles it is required to have a high number of projections, whereas less projections can suffice for the remainder of the 360° rotation. The shape of the object as well as the requirements on the detectability of defects and measurement accuracy may serve as input. This ESR will subsequently develop associated reconstruction algorithms. Also, new standard interfaces for Industry 4.0 shall be developed that answer the need for automated utilization of new scanning strategies in CT scanners without human intervention.

Expected results

- Demonstrator software of a novel method that computes advanced scanning strategies based on part

information (e.g. CAD) and defect detectability and measurement accuracy requirements;

- Reconstruction algorithms for the obtained non-traditional scanning trajectories;
- Validation of the methods on academic parts as well as on an industrially relevant case study;
- PhD dissertation.

Credibility

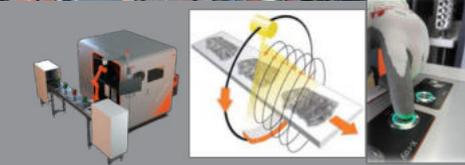
Prior work has indicated that certain project angles are more relevant than others, depending on the features of the scanned object. Therefore, it should be possible to derive these angles based on a priori information of the object, and to adapt the reconstruction accordingly.

Planned secondments

- Nuovo Pignone International Ltd.: in-depth study of end-user requirements and working procedures;
- RWTH Aachen University: validation of methods on academic workpieces; academic experience, PhD trainings.
- Fraunhofer Institute for Integrated Circuits IIS: collaborate with ESR4 on integrating digital twin elements.



Waygate
Technologies



Vacancy ESR10

Germany

ESR host

Waygate Technologies GmbH

Niels-Bohr-Str. 7

Wunstorf, 31515

Germany

ESR host

Centrum Wiskunde &
 Informatica

Science Park 123
 Amsterdam, 1090 GB
 Netherlands



Vacancy ESR11

Netherlands

Fast scanning strategies for conveyor-belt setups

Objectives

To develop advanced computed tomography (CT) reconstruction algorithms for conveyor belt setups with fixed X-ray source and detector (limited-angle CT), based on computing focal stacks and incorporating prior knowledge either explicitly or through deep learning. The approach will be based on recent developments in the field of plenoptic (lightfield) imaging, where the authors from NWO-I have developed a computational method for deriving focal stacks from limited-angle tomographic data. This allows to effectively detect and segment object features situated at a particular depth in the object. As the data has strong limitations, incorporation of prior knowledge will be essential, which will be developed in collaboration with ESRs 2, 3 and 10.

Expected results

- Suite of reconstruction methods specifically targeted for the linear conveyor-belt geometry, implemented using the ASTRA

toolbox as a building block platform, that can be shared throughout the network;

- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in WPI (autonomy) as well as with other ESRs (applications);
- PhD dissertation.

Credibility

The application of both prior knowledge and deep learning on limited-angle CT data is expected to improve upon conventional reconstruction techniques (e.g. backprojection, algebraic reconstruction or statistical reconstruction).

Planned secondments

- Accent Pro 2000: initial implementation and testing of methods on prototype CT scanning set-up.
- University of Padova: validation of methods on academic workpieces; university experience, PhD trainings. Collaborate with ESR 8 on performance evaluation of the developed method.

Adaptive angle-selection for in-line CT

Objectives

To develop computational techniques for robotic CT (computed tomography) scanners that allow to decide in real-time during scanning which are the 3D regions in the object that are most relevant to the specific investigation, such that the trajectory of flexible scanners can be adapted to zoom into the specific regions-of-interest and to adapt to the presence of dense or very thick structures by changing the axis of rotation on-the-fly. The ESR will target fully in-line trajectory optimization, in contrast to current state of the art where novel scan strategies can only be decided after processing of the tomographic data. NWO-I has recently developed a novel approach for combining tomographic data from multi-orientation trajectories, which has proven highly effective for dealing with artefacts due to dense metallic structures), which will be used as the basis for the autonomous adaptation approach.

Expected results

- Suite of geometry adaptation methods implemented for real-

time performance using the ASTRA toolbox as a building block platform, that can be shared throughout the network;

- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in WPI (autonomy) as well as with other ESRs (applications);
- PhD dissertation.

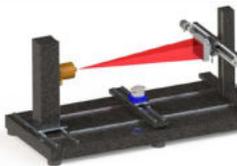
Credibility

The next generation of graphics processing unit (GPU) hardware as well as the use of efficient novel programming techniques make it possible to apply these calculations on-the-fly.

Planned secondments

- Waygate Technologies: collaboration with ESR10 on defining criteria to optimize flexible trajectories.
- KU Leuven: validation of methods on academic workpieces; academic experience, PhD trainings. Collaborate with ESR 2.
- Accent Pro 2000: validation on flexible CT systems.

CWI



Vacancy ESR12

Netherlands

ESR host

Centrum Wiskunde &
Informatica

Science Park 123
Amsterdam, 1090 GB
Netherlands

ESR host

Materialise nv

Technologielaan 15
 Heverlee, 3001
 Belgium



Vacancy ESR13 Belgium

CT based process planning and build preparation for Additive Manufacturing

Objectives

Autonomously correlate in-line computed tomography (CT) data with AM process parameters which are decided on during build preparation. This ESR will perform a large number of experiments on the Materialise Control Platform (MCP) Laser Sintering machine, varying the environmental settings and the machine settings (scanning pattern, laser power, and laser scan velocity). Deep learning techniques will be used to correlate the in-process monitoring models with the post-process CT data. The scope of this correlation is to identify the sensor output data range that yields adequate part quality. This ESR will concentrate on identifying correlations between the input process parameters (machine settings) and the CT data by developing AM simulation techniques that are nurtured by the results of ESR14.

Expected results

- Demonstrator software

implementation giving feedback to build preparation about the expected quality + guidelines on how to optimize the build preparation;

- Validation of the methods on academic parts as well as on an industrially relevant case study;
- Joint publications with the other ESRs working in WP4 as well as with other ESRs (applications);
- PhD dissertation.

Credibility

The extensive experience in additive manufacturing at the host institution, as well as the close collaboration with KUL's AM and CT research groups ensures that this challenging objective will be met.

Planned secondments

- KU Leuven: collaboration with ESR13 on coupling results also to in-line monitoring data;
- University of Applied Sciences Upper Austria: collaboration with ESR7 on autonomous pipeline, to be used for integrated in-line feedback to manufacturing process planning.

Computer Tomography based improvement of in-process monitoring capabilities

Objectives

Autonomously correlate in-line CT data with AM process parameters which are decided on during build preparation. To quantify variations in the process, all experiments will be monitored in-line using e.g. thermal and optical imaging. The monitoring data will be stored in a database (according to an appropriate data model), and the manufactured parts will be CT scanned. This ESR will stack the monitoring data, which is acquired for every layer of the process, to produce a 3D volumetric model. Deep learning techniques will then be used to correlate the in-process monitoring models with the post-process CT data. The scope of this correlation is to identify the sensor output data range that yields adequate part quality. This ESR project will interpret the CT scans of the experimental parts, combine the CT results with the monitoring data, in order to develop predictive models to be used in build preparation.

Expected results

- Validated demonstrator software implementation of the learning system for establishing and updating the correlations;
- Joint publications with the other ESRs working in WP4 (integration) as well as with other ESRs (applications);
- PhD dissertation.

Credibility

Exploratory research has indicated a correlation between porosity determined by CT and AM process parameters, which is taken a step further through this research by making the process more user-independent..

Planned secondments

- Materialise NV: collaboration with ESR12 on coupling results also to build preparation.

KU LEUVEN



Vacancy ESR14

Belgium

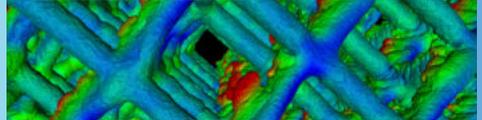
ESR host

KU Leuven - MaPS
Celestijnenlaan 300, bus 2420
Leuven, 3001
Belgium

ESR host

University of Padova

Padova, 35123
 via VIII Febbraio, 2
 Italy



Vacancy ESR15
Italy



CT-based adaptive advanced manufacturing and assembly chains

Objectives

Realizing CT-based adaptive manufacturing and assembly chains, by integrating advanced manufacturing (including 3D printing), innovative assembly and smart Computer Tomography (CT) techniques. Develop a CT-based pipeline to autonomously provide feedback to advanced manufacturing and to identify matching components that fulfil tolerance requirements for the assembly. To make this feasible for industrial implementation, the work will focus on obtaining fast but reliable dimensional measurements focusing on specific regions of interest that interact with other components during assembly. The pipeline is expected to be fully autonomous yet flexible enough to be adapted in accordance with a realistic Industry 4.0 scenario.

Expected results

- Method for CT metrology assisted

manufacturing and assembly;

- Validation of the methods on specific case studies;
- Joint publications with the other ESRs (Early Stage Researchers);
- PhD dissertation.

Credibility

The Research Group has extensive experience and world-class reputation in precision manufacturing, industrial metrology and innovative CT. The University of Padova is one of Europe's oldest and most prestigious seats of learning, and is ranked first among leading Italian universities for quality of research.

Planned secondments

- University of Applied Sciences Upper Austria: collaboration with ESR 7 on using the autonomous CT pipeline for realizing integrated CT based adaptive manufacturing and assembly.
- Materialise: application of CT metrology for additive manufacturing and industrial experience.