### Scholarship Reference

**A-Adige SPA**

### Company

**ADIGE SPA – via Per Barco, 11 - 38056 - LEVICO TERME (TN)**

### Type of Scholarship

**Level 2**

For students enrolled in Computer Science or Artificial Intelligence Systems Master Programs

### Title of Scholarship

Three thematic options are made available:

- **A1:** Classification of generic 2D profiles shapes and definition of a computational solution for a feasible laser cutting sequence

- **A2:** Estimation of the manufacturing time of a generic 3D part on a laser tube machine, using a hybrid analytical-statistical approach

- **A3:** Automatic positioning of a free-form workpiece in 3D space for optimal laser processing in a robotized cell

### Industrial Tutor (full name + email address)

Paolo Benatti – [paolo.benatti@blmgpoup.it](mailto:paolo.benatti@blmgpoup.it)

### Academic Supervisor (full name + email address)

To Be Defined
Option A1

Short Description of Internship and Thesis Activities, and Expected Outcome:

The computation of an optimal laser cutting path for generic parts is currently completely automatic in case of metal tubes or profiles having a regular shape (round, square, rectangular, obround…). On the contrary, there is no automatic solution to compute a feasible and sub-optimal cutting path for profiles having special generic shapes, able to satisfy both the geometrical and the technological constraints.

In fact, there are many technical aspects which affect the definition of a reliable cutting trajectory in case of a generic “special” 2D section (interference between the part and the cutting head, flow of laser assistance gas on material surface, distance between the nozzle and the part, etc).

Scope of this Thesis is to study a large collection of existing, manually defined solutions, classify them and infer the underline rules for a feasible manufacturing, in order to compute an automatic trajectory path solution for special profiles.

The approach for the classification and the definition of the operational logic can be either classical, i.e. based on geometrical and topological analysis of the profile shape, or based on Artificial Intelligence solutions, e.g. Neural Networks of any kind.

The Expected Outcomes of this activity are:

- The classification of generic 2D shapes, stored in an existing database filled by expert technicians, clustering those that have similar cutting logic
  - This can be done using an AI solution or a more classical cluster analysis approach, like:
  - The identification of a finite number of numerical properties of a 2D generic shape, creating a correspondence between the shape and a point in a hyperspace
  - The definition of a metric in this hyperspace, where the distance between (the points corresponding to) two shapes expresses the “similarity” of these two shapes in term of geometrical and technological constraints (i.e. laser cutting paths have similar logic)
  - The Development of an algorithm, or an AI solution, able to find the group of shapes in the cluster which is “nearest” (more similar) to a given shape

This could lead to the development of a general algorithm, an AI solution, able to automatically compute a feasible cutting path sequence for any generic 2D shape.

Required Candidate Skills and Prerequisites:

The candidate should have acquired some theoretical knowledge of:

- Computational Geometry
- Cluster analysis, Data mining
- Machine learning, Artificial Intelligence, Neural Networks

Our technicians will provide training to reach a basic competence on laser cutting technology and related constraints.

The candidate will work in cooperation with our Software Department, for the definition and implementation of the system and its underlying algorithms, and with our Application Engineers, for the analysis of the existing solutions and the tests of the outcomes on a group of new generic shapes.

The proposed topics have been summarized to fit the form provided by UNITN. Interested students will be able to better explore the proposals with the company managers involved, in order to satisfy training needs and expectations.
One of the most important information for users of automatic machines is the estimation of the manufacturing time of a given piece.

In fact, the processing time determines the production cost, which in turn allows a preliminary evaluation of the price at which (the production of) that piece can be offered to the market. A bad estimation of machining time (too high or too low) can lead to the loss of an order or, even worse, to a lost profit.

Unfortunately, for some technology (like lasertube machines), the estimation of production time with an analytical model is not an easy task, because there are many variables that influence the behaviour of the machine, affecting its efficiency: the creation of a digital-twin machine model is very complex.

A possible alternative solution to this problem is the exploitation of a statistical approach: given a large database of real data, collected from many machines on different parts with different materials and shapes, manufacturing time could be estimated by the extrapolation of the production time of “similar” parts, produced in “similar” condition (e.g: same machine model and capability).

Scope of this Thesis is to combine in a hybrid approach a preliminary geometrical analysis of a 3D part model, matching its geometrical features with a large database of real production data on a statistical base.

The candidate shall define some appropriate indicators to be automatically extracted by a geometrical analysis of a generic 3D part (like the shape of tube profile, the number of cutting geometries, the total cutting length, etc) and use these indicators to find the most similar parts produced in the past on the same material and obtain a range of min-max estimated production time, computed on the basis of their real production time.

The approach for the classification of the parts can be either classical, i.e. based on geometrical and topological analysis of the part itself, or based on Artificial Intelligence solutions, e.g. Neural Networks of any kind.
The Expected Outcomes of this activity are:
- The classification of the parts stored in an existing database filled by expert technicians, clustering those having “similar” features
  This can be done using an AI solution or a more classical cluster analysis approach, like:
  o The definition of a finite number of indicators which identify the most important features of a given part (imported as a 3D model), creating a correspondence between the part and a point in a hyperspace
  o The definition of a metric in this hyperspace, where the distance between (the points corresponding to) two parts expresses the “similarity” of these two parts in term of production time
- The Development of an algorithm, or an AI solution, able to find the group of parts in the cluster which is “nearest” (more similar) to any given part and the computation of an estimated production time range (min-max) for this part.

Required Candidate Skills and Prerequisites:

The candidate should have acquired some theoretical knowledge of:
- Computational Geometry
- Cluster analysis, Data mining
- Machine learning, Artificial Intelligence, Neural Networks

Our technicians will provide training to reach a basic competence on laser cutting technology and related constraints

The candidate will work in cooperation with our Software Department, for the definition and implementation of the system and its underlying algorithms, and with our Application Engineers, for the analysis of the existing solutions and the tests of the outcomes on a group of new generic parts.

The proposed topics have been summarized to fit the form provided by UNITN. Interested students will be able to better explore the proposals with the company managers involved, in order to satisfy training needs and expectations.
Option A3
Short Description of Internship and Thesis Activities, and Expected Outcome:

The manufacturing of a generic freeform workpiece using laser processes, like cutting and welding, is strongly dependent on the position and orientation of the part in the working space of the robotized cell.

In fact, to have a feasible laser process, each point along the cutting/welding path must be reachable by the laser tool with the correct orientation, respecting physical and technical constraints, like:

- Reachability by the tool (depending on the robot kinematics)
- Crossing of singularity points
- Interference among any of the objects in the cell
- Entanglement of cables and pipes
- Constant speed of the tool along its path (with respect to the technological process speed)

This is especially important for anthropomorphic robots, whose reachability space is not regular and (unfortunately) not very precise in absolute.

Scope of this Thesis is to map the space in the cell in term of reachability and precision and define a logic to match this space against the workpiece processing path, in order to compute the minimum number of positions/orientations of the part which allows the end effector of the robot to follow every point of the toolpath, respecting the aforementioned constraints.

The Expected Outcomes of this activity are:
- The preliminary analysis of the reachability space of a given robotized cell
- The analysis of a certain number of real parts already processed by expert technicians, with the aim to generalize the logic behind their position and reposition in cell space. This can be done using an AI solution or a more classical geometrical approach.
- The Development of an algorithm, or an AI solution, able to compute the minimum set of workpiece positions which allow full toolpath laser manufacturing

Required Candidate Skills and Prerequisites:

The candidate should have acquired some theoretical knowledge of:
- Computational Geometry
- Robotics and Kinematics
- Machine learning, Artificial Intelligence, Neural Networks

The candidate will work in cooperation with our Software Department, for the definition and implementation of the system and its underlying algorithms, and with our Application Engineers, for the analysis of the existing solutions and the tests of the outcomes on a group of new 3D workpieces.

The proposed topics have been summarized to fit the form provided by UNITN. Interested students
will be able to better explore the proposals with the company managers involved, in order to satisfy training needs and expectations.