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IC2019_Spring BCAM International Call

BCAM - Lantek PhD Position in 2D and 3D packing with curved geometries

Job Offer	
Topics:	2D and 3D packing with curved geometries **Keywords:** Computational mathematics, geometric modeling, 2D and 3D nesting problem, boundary B-spline representation, curvature matching, metal sheet cutting
PhD project thesis	The goal of this project is to develop a unified computational framework for 2D and 3D nesting of polygonal and curved (free-form, NURBS) objects. The proposed project consists of 4 stages. 1. Implement state-of-the-art algorithms for polygonal 2D nesting (D function, Phi-function, Non-fitting polygon). The algorithms will be implemented using a publicly free software, e.g. CGAL (https://www.cgal.org) or Irit (http://www.cs.technion.ac.il/~irit/). 2. The C/C++ code will be exported to the commercial software Expert (Lantek) and tested against the state-of-the-art algorithms. Path-planning algorithms to minimize the cutting time will also be investigated. Physical validations of the algorithm will be realized in Lantek. 3. 2D generalization towards curved objects and boundaries. Boundary representation (B-spline, NURBS) will be used and smooth shape descriptors (curvature) will be applied to design algorithm for highly accurate local matching. 4. Generalization to 3D. Sphere packing problem with curved boundaries.
PhD advisors:	• **Dr. Michael Barton (BCAM)** https://bit.ly/2FdEMt8 • **Dr. Angel Gimenez (Lantek)** https://bit.ly/2TNC9bM
Research Area:	***Computational Mathematics***
Background:	2D packing (aka nesting) problem is a classical problem in computational geometry with a wide variety of industrial applications such as optimal packing tool boxes or metal sheet cutting. Given a set of 2D objects and a 2D container, the objective is to include (nest) the objects from the set into the container in a non-overlapping manner such that the residual space (waste material in the context of metal sheet cutting) is minimized. The problem is well-studied for the case of a

rectangular container and polygonal objects to be nested [1-4]. Various algorithms exist (pixel/rasterization methods, D-function, non-fitting polygon methods, phi-function, etc.), however, the problem is known to be NP-complete and therefore most of the algorithms use certain heuristics to select the objects from the list [3].

Recently, a generalization towards non-convex containers with curved boundaries has been made for a special case where all the internal objects are circles [5]. The circular geometry admits simple formulation of the problem (via circle's centers and their distances), which is used for an initialization where every two circles are sequentially complemented with the third one that has tangential contact with both of them. Once the container is filled with sets of circles where each one possesses tangential contact with another two circles (or the curved boundary), the optimization that mimics shaking the container is applied to create space for additional circle(s).

The aim of this Phd fellowship is to further investigate the 2D packing problem in terms of efficient implementation, generalization to curved geometries, and the 3D case. In the first part of the project, we will use phi-functions [4] to optimize the computation of collisions between 2D shapes. Then, the state-of-the-art heuristic techniques (such as simulated annealing or genetic algorithms) will be applied to speed-up the computation. A path-planning to minimize the cutting time will also be investigated. In the second part of the project, we look into generalized variants of the problem, namely to consider curved containers (domains), and curved, free-form (NURBS) objects. We aim to use boundary representation (B-spline, NURBS) of the curved objects and apply geometric descriptors such as curvature to find parts of curves that fit locally (up to the second order). Finally, we aim to tackle the 3D generalization of the curved variant of the nesting problem, at least for simple and congruent objects such as spheres and ellipsoids.

References:

[1] Burke, Edmund K., et al. "Complete and robust no-fit polygon generation for the irregular stock cutting problem." European Journal of Operational Research 179.1 (2007): 27-49.

[2] Chen, Ping, et al. "Two-Dimensional packing For Irregular Shaped Objects." null. IEEE, 2003.

[3] Bennell, Julia A., and Jose F. Oliveira. "The geometry of nesting problems: A tutorial." European

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	Journal of Operational Research 184.2 (2008): 397-415. [4] Stoyan, Y., Scheithauer, G., Gil, N. and Romanova, T., 2004. $\Phi $-functions for complex 2D-objects. Quarterly Journal of the Belgian, French and Italian Operations Research Societies, 2(1), pp.69-84. [5] Machchhar, J., & Elber, G. (2017). Dense packing of congruent circles in free-form non-convex containers. Computer Aided Geometric Design, 52, 13-27.
Salary and conditions:	**The gross annual salary of the Fellowship will be 18.000 €.** It will then be on your own responsibility to make your yearly income declaration at the Bizkaia Treasury Agency. There is a moving allowance for those researchers that come from a research institution outside the Basque Country from EUR 500 to EUR 1.000 gross. *Free access to the Public Health System in Spain is provided to all employees.*
No Positions offered:	**#1**
Contract and offer:	**4 years**
Deadline:	**April 30th, 2019, 12:00 CET (UTC+1)**
How to apply:	Applications must be submitted on-line at: http://www.bcamath.org/en/research/job

Scientific Profile Requested	
Requirements:	• Promising young researchers. • Master degree in Mathematics or Computer Science (Computer Science background preferable). • The candidate must have his/her Master Degree completed before the incorporation. • Applicants must have an excellent academic record.
Skills and track-record:	• Experience in programming (C/C++). • Good communication and interpersonal skills. • Ability to effectively communicate and present research ideas to researchers with different background. • Ability to clearly present and publish research outcomes in spoken (talks) and written (papers) form. • Good command of spoken and written English.

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Application and Selection Process	
Formal Requirements:	The selected candidate must have applied before the application deadline online at the webpage http://www.bcamath.org/en/research/job The candidates that do not fulfil the mandatory requirements will not be evaluated with respect to their scientific profile. The candidate will take part in a collaborative project between BCAM and Lantek.
Application:	Required documents: ▪ CV ▪ Letter of interest ▪ 2 recommendation letters
Evaluation:	Based on the provided application documents of each candidate, the evaluation committee will evaluate qualitatively: the adaption of the previous training and career to the profile offered, the recommendation letters, the main results achieved (papers, proceedings, etc.), the statement of past and proposed future research and other merits; taking in account the alignment of these items to the topic offered.

Incorporation:	**Summer 2019 or as soon as possible thereafter.**