

# Research and education systems of European universities concerned with laser welding and friction stir welding

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## Introduction

Friction Stir Welding (FSW) and Laser Welding (LW), as two advanced joining processes, have evolved since their invention and are used not only in joining but also in material processing [1,2]. The potential of these technologies for joining and processing has prompted many universities all around the world to invest in educational and research programs. The current study is focused on research and education plans of the European universities in relation to these joining technologies. Top universities in 10 European countries were selected to see whether these topics are taught or are under research.

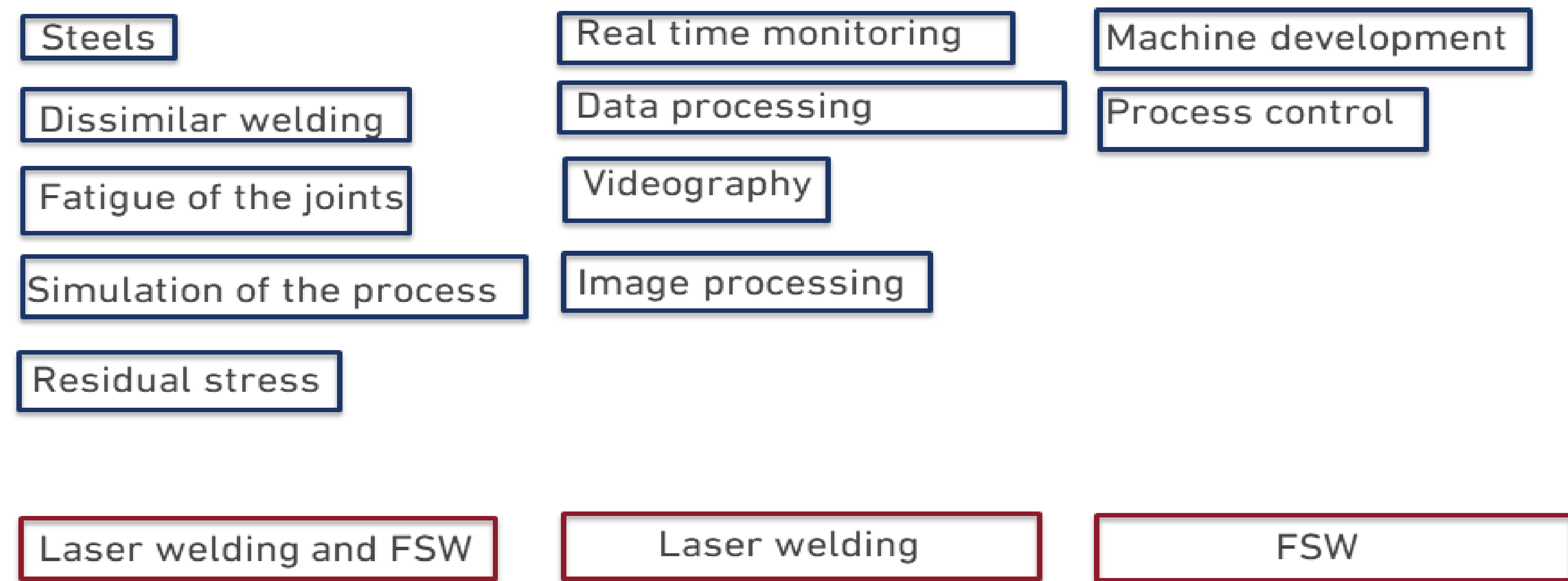


Figure 2 – The research areas related to FSW and LW in the European universities.

## Methodology

The main activities of the universities in the field of FSW and LW were determined through searching the syllabuses and the latest publications in the field. The countries and universities with their rankings are shown in Figure 1.

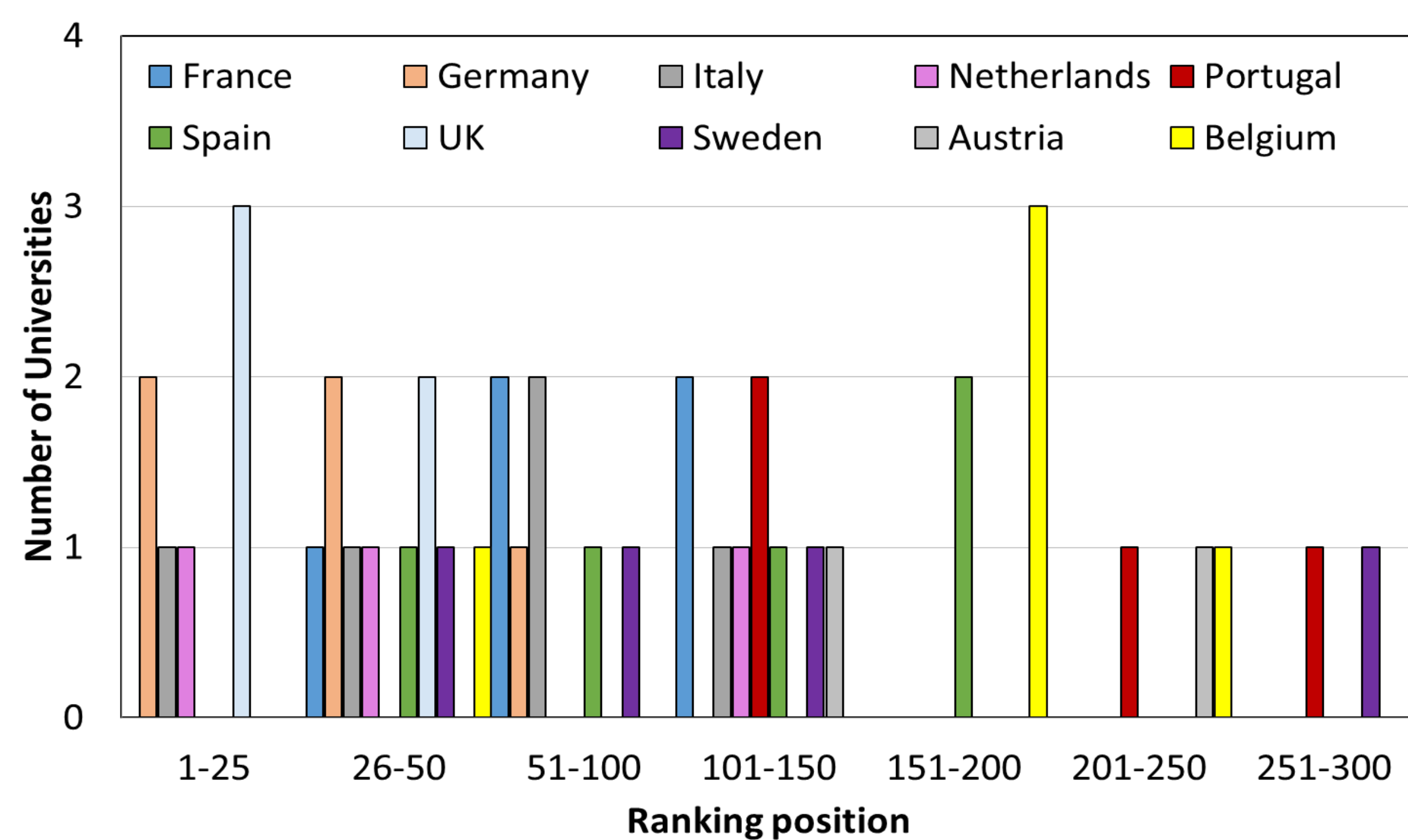


Figure 1 – Ten countries with the rankings of their top universities.

Figure 3 shows the distribution of top universities in Europe wherein welding courses are taught. The darker the color of the country, the more the number of the top universities concerned with welding.

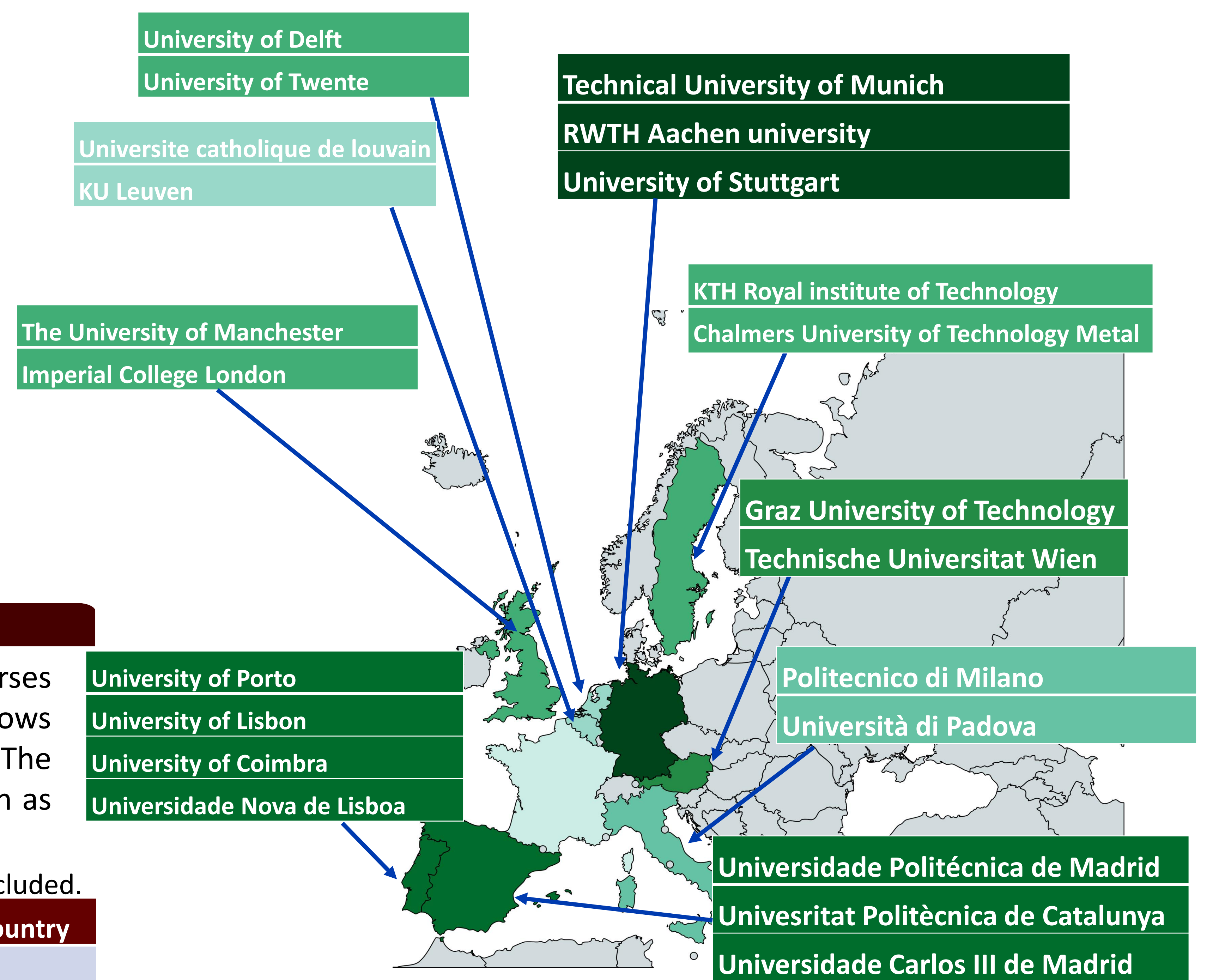


Figure 3 – Distribution of top universities in Europe wherein welding courses are taught.

## Results

In terms of courses, we have found that there are almost no courses dedicated exclusively to these processes (see Table 1). Figure 2 shows the research areas which are undertaken at European universities. The research projects on these processes cover a variety of majors such as metallurgy, mechanics, and computer science.

Table 1. List of courses containing welding processes with FSW and LW included.

Course title	University	Country
Joining processes	The University of Manchester	UK
Introduction to Manufacturing Processes	Imperial College London	
Welding process	Graz University of Technology	Austria
Special welding process Qualitätssicherung in der Schweißtechnik		
Welding Science and Technology	Universite catholique de louvain	Belgium
Welding Science and Technology	Universidade Politécnica de Madrid	Spain
Welding processes	Univesitat Politècnica de Catalunya	
Welding Technology I	Technical University of Munich	Germany
Laser Technology and laser technology tutorial	Technical University of Munich	
Joining technology	Technical University of Munich	
Advanced manufacturing processes	Politecnico di Milano	Italy
Welding and joining technologies	Università di Padova	
Introduction to Joining of Structures and Manufacturing	University of Delft	Netherlands
Welding technology	University of Porto	Portugal
Metal Bonding Processes	University of Porto	
Curso de Técnicas de Soldadura	University of Lisbon	
Advanced Welding Technologies	University of Coimbra	
Several courses specific to welding	KTH Royal institute of Technology	Sweden

## Conclusions

Two advanced joining processes, LW and FSW, are taught in a few universities mainly under more general courses related to either welding and joining or manufacturing. The research projects on these two processes are vast and cover a variety of specialties such as metallurgy, mechanics, physics, data analysis, and computer science meaning that these processes are multidisciplinary topics.

## References

- [1] Böhm C, Hagenlocher C, Wagner J, Graf T, Weihe S. Analytical description of the criterion for the columnar-to-equiaxed transition during laser beam welding of aluminum alloys. *Metallurgical and Materials Transactions A*. 2021 Jul;52(7):2720-31.[2] Costa, M, Carbas, R, Marques, E, Viana, G, da Silva, LFM, *Theoretical and Applied Fracture Mechanics* 91 (2017): 94-102.
- [2] Pouraliakbar H, Beygi R, Fallah V, Monazzah AH, Jandaghi MR, Khalaj G, da Silva LF, Pavese M. Processing of Al-Cu-Mg alloy by FSSP: Parametric analysis and the effect of cooling environment on microstructure evolution. *Materials Letters*. 2022 Feb 1;308:131157.