PhD Title: Veggie Breizh Bot Assistive Robot for Cooking **Collaboration- Partnership:** Instituto Superior Técnico (Lisbon, Portugal) Chaire Maintien @ Domicile **IMT Atlantique : Campus** ☒ **Brest** ☐ **Nantes** ☐ **Rennes** **Laboratory:** Lab-STICC **École doctorale :** ☒ **SPIN** ☐ **3MG** **Financement - Funding:** Brest Métropole, Instituto Superior Técnico	IMT Atlantique Bretagne-Pays de la Loire École Mines-Télécom TÉCNICO LISBOA CHAIRE M@D Maintien @ Domicile

Academic context :

IMT Atlantique, internationally recognized for the quality of its research, is a leading general engineering school under the aegis of the Ministry of Industry and Digital Technology, ranked in the three main international rankings (THE, SHANGHAI, QS). Located on three campuses (Brest, Nantes, and Rennes), IMT Atlantique aims to combine digital technology and energy to transform society and industry through training, research and innovation. It aims to be the leading French higher education and research institution in this field on an international scale. With 290 researchers and permanent lecturers, 1000 publications and 18 M€ of contracts, it supervises 2300 students each year and its training courses are based on cutting-edge research carried out within 6 joint research units: GEPEA, IRISA, LATIM, LABSTICC, LS2N and SUBATECH. The proposed thesis is part of the research activities of the RAMBO team (Robot interaction, Ambient systems, Machine learning, Behaviour, Optimization) of the Lab-STICC laboratory, and of the Computer Science Department of IMT Atlantique.

Institute for Systems and Robotics (ISR Lisboa) is a Research, Development and Innovation (RD&I) institution that was founded in 1992. At ISR Lisboa research groups develop advanced multidisciplinary research activities, in the areas of Robotic Systems and Information Processing. ISR offers an inspiring, multinational and multicultural research ecosystem with over one hundred researchers engaged in cutting-edge research, training and outreach activities. ISR is affiliated to **Instituto Superior Técnico (IST)** — the largest school of Architecture, Engineering, Science and Technology in Portugal, involving a community of over 10,000 people. IST, founded in 1911, is part of the University of Lisbon, and is ranked amongst the top schools of engineering in Europe. It aims to contribute to the development of society, promoting excellence in higher education, and by developing Research, Development and Innovation (RD&I) activities.

Context and state-of-the-art:

The RAMBO team is studying how ambient devices and robots can develop increasingly complex skills based on active learning, artificial curiosity and interactive learning, to enable robots to learn continuously in open, connected environments and in interaction with humans. Targeted areas of applications include the development of services for people who are dependent (because of their age or disability) to enable them to continue to live independently.

The team is a founding member of the "Maintien à Domicile" chair (M@D), and contributes to the "Future investment programme" (PIA) project "Handicap Innovation Territoire" (HIT). The team is a member of the "Interaction" cluster and participates in the AI (Artificial Intelligence) transversal program of the Lab-STICC.

This thesis is a continuation of the work on home robotic assistance carried out by the M@D Chair, in particular on meal preparation assistance. [2, 6, 1]

Objectives of the thesis and expected contributions

The aim of this project is to improve quality of life through active help with food preparation. The objective is to solve the problems associated with preparing a meal using a humanoid robotic arm. The scientific questions that will be addressed are:

- What set (library) of movements is needed to cook (e.g. unpacking, weighing, washing, cutting, mixing, cooking, serving, cleaning, etc.)?

- How to digitally represent cooking gestures and enable non-specific robots to carry them out?

- How to manage the variability in the shape of utensils and ingredients during the execution of these gestures?

- How to keep the food processor and its sensors clean and hygienic throughout the cooking process?

As a robotic platform, we will be using a Jaco arm from Kinova (acquired by our laboratory thanks to the CPER VITAAL) which, as well as having 6 degrees of freedom enabling it to reach any point in the workspace, has the advantage of being able to measure force feedback using torque sensors.

As practical constraints, we propose to use a single robotic arm (this reduces the cost of the system and the complexity of bi-manual control, but requires creative solutions for carrying out the tasks) with a limited payload. We allow passive objects (utensils) and active objects (ovens, plates, taps, etc.) to be used in the environment, as well as any static accessories specifically designed for robotic use (e.g. an accessory for holding the ingredient to be peeled).

As an end-of-project demonstration, we plan to prepare a complete vegetarian meal (starter, main course, dessert). The choice of preparing vegetarian dishes has the practical advantage of simplifying product handling by avoiding the handling of meat and the associated hygiene problems.

With regard to the expected scientific results, we hope to identify (1) a set of gestures sufficient for cooking, and (2) an appropriate representation for these gestures.

In terms of methodology, we will explore learning by demonstration and the representation of gestures using Dynamic Motion Primitives (DMP) [7]. In particular, DMPs enable impedance control for so-called *compliant* movements.

As far as potential risks are concerned, we expect to be faced with a slower pace of execution than that of humans, which will have to be taken into account when scheduling the cooking phases.

Technically, we will be faced with the difficulty of representing the effects of actions, such as *peeling*, on the ingredients being manipulated, in the absence of a quality geometric model.

From a control point of view, some gestures may not be feasible with a single robotic arm. In this case, we will use human-robot collaboration to ask for help with these tasks.

Environmental impact of the project:

In addition to the scientific research questions explored, the use case chosen in this project will focus on the preparation of vegetarian dishes. It will offer a solution to help reduce meat consumption - one of the major factors contributing to global warming [5], and a necessary action to meet France's commitment to reduce its greenhouse gas emissions by 2050 [8].

In addition, it will bring the health benefits of a plant-based diet, eliminating factors that contribute to health risks (e.g. the risk of colorectal cancer, currently responsible for 12.7% of cancers in Europe [3], the second leading cause of cancer deaths after lung cancer, linked in particular to the consumption of red meat and processed meat [4]).

Candidate profile and required skills:

• Master Degree in Computer Science or Robotics (or equivalent)

• Programming and Software Engineering skills (Python, Git, Software Architecture Design)

• Robotic programming skills (ROS)

• Data science skills

• Machine learning skills

• English speaking and writing skills

References:

[1] Samia Benferhat. Ingénierie de services domotiques pour l'intégration de cobots dans un environnement d'assistance à la personne. Projet de thèse. 2023. url : https://www.theses.fr/s210213

[2] Samia Benferhat, Florent Frizon de Lamotte, Christophe Lohr et Jean-Luc Philippe. « Gestion d'interaction Humain-Cobot pour l'exécution de tâches en cuisine ». In : JETSAN 2021 – Colloque en Télésanté et dispositifs biomédicaux - 8ème édition. Université Toulouse III - Paul Sabatier [UPS]. Toulouse, Blagnac, France, mai 2021. url : https://hal.science/hal-03501202

[3] European Commission. Colorectal Cancer Factsheet. Mars 2021. https://ecis.jrc.ec.europa.eu/pdf/Colorectal_cancer_factsheet-Mar_2021.pdf

[4] Centre de lutte contre le cancer Léon Bérard. Cancérogénicité de la consommation de viande rouge et de viande transformée. Juill. 2022. https://www.cancer-environnement.fr/fiches/publications-du-circ/monographies-vol-114-cancerogenicite-consommation-viande-rouge-et-viande-transformee/

[5] Martin C. Parlasca et Matin Qaim. « Meat Consumption and Sustainability ». In : Annual Review of Resource Economics 14.1 (oct. 2022), p. 17-41. doi : 10.1146/annurev-resource-111820-032340. url : https://doi.org/10.1146/annurev-resource-111820-032340

[6] Farida Saïd, Jeanne Villaneau, Samia Benferhat, Arnaud Biger, Thibault Celeste, Valentin Cadou et Kevin Philippe. Graphe de connaissances pour l'aide à la réalisation de recettes de cuisine. Sous la dir. de Revue des Nouvelles Technologies de l'Information. EGC' 2023. Poster. Extraction et Gestion des Connaissances, jan. 2023. url : https://hal.science/hal-03976515

[7] Matteo Saveriano, Fares J Abu-Dakka, Aljaz Kramberger et Luka Peternel. « Dynamic movement primitives in robotics : A tutorial survey ». In : arXiv preprint arXiv:2102.03861 (2021).

[8] Ministère de la Transition écologique et de la Cohésion des territoires et Ministère de la Transition énergétique. Stratégie Nationale Bas-Carbone (SNBC). Juill. 2022. https://www.ecologie.gouv.fr/strategie-nationale-bas-carbone-snbc

Work Plan:

The thesis is due to start in autumn 2023, and is expected to last 36 months. Temporally, it will be divided into two periods of around 18 months at each of the partners' sites. More specifically, it will be structured as follows (indicative schedule):

• Defining the library of actions required for cooking (M0-M1)

• Proposal of a formalism to represent these gestures in an operational and adaptive manner (i.e. usable by robots with different characteristics) (M4)

• Execution of a reduced set of robotic gestures to validate the choice of formalism (M8)

• Proposal of algorithms to deal with variability of utensils and ingredients for task planning and execution (M16)

• Design of static accessories to facilitate the robot's work (M16-M18)

• Transfer of the PhD student to the partner institution (M18)

• User tests (M24)

• Writing articles and scientific dissemination (M24-32)

• Preparation of the end-of-thesis demonstration (M32-M36).

How to apply?

To apply for this position, please send a detailed application including:

- an up-to date CV,
- a cover letter,
- transcripts of grades,
- reference letters

to mihai[dot]andries[at]imt-atlantique.fr and christophe[dot]lohr[at]imt-atlantique.fr.

Additional information :

- Application deadline : **1 October 2023**

- Start date for the thesis: 1 December 2023
- Contract duration: 36 months
- Location : 18 months in Brest (France) and 18 months in Lisbon (Portugal)
- Contact(s) :

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