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► **To cite this version:**

Cristina Stoica Maniu, Sylvain Bertrand. Artistic consensus for mobile robots. Virtual Festival "WÆ – womxn from arts to engineering", Berlin, 6-7 October, 2022, 10.14279/depositonce-17883 . hal-03828485

HAL Id: hal-03828485

<https://hal.science/hal-03828485v1>

Submitted on 14 Dec 2022

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Artistic consensus for mobile robots

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Abstract

In order to keep our teaching modules attractive for the students, motivating examples are proposed offering them the possibility to combine Arts and Engineering problems. This paper focuses on artistic consensus in the context of two teaching modules on multi-agent systems. In these modules, our students learn the notion of consensus and they implement consensus strategies both in simulation and on real mobile robots. Several artistic consensus choreographies were proposed by the students during the practical sessions.

1 Mixing Arts and Control

Numerous persons had to decide at one moment if they continue with an artistic or an engineering career, and sometimes this choice is not obvious. It could be interesting to allow future engineers to enhance their creativity, to improve their visualizing ability, to get inspired for technical improvements [1], and also to have fun during their learning activities in order to better retain the scientific concepts during their curriculum.

In this context, we proposed new teaching modules at CentraleSupélec¹: “Dynamical Multi-Agent Systems. Application to drones formation control” [2] (for the 2nd year students) and “Control architectures of complex systems” (for the 3rd year students, equivalent Master level). These modules are on control strategies for multi-agent systems, with a particular focus on consensus strategies, combining theoretical concepts with a strong link to applications and practice on mobile robots (e.g. drones or ground mobile robots). These teaching modules are divided in lectures, tutorials and 9h or 6h of case studies. During the case studies, the students work in small groups (free choice of team-mates) and propose their own subject (practical application) related to the module content. Based on the case study results, the students write a report and an interactive poster, which are further used for the assessment process (i.e. interactive poster session, with peer assessment and assessment by the pedagogical team).

During the practical work session, direct application of consensus algorithms for distributed control of Multi-Agent Systems are considered in a 4-step pedagogic approach: 1. definition of the communication graph and control law (simulation with 2D agents with Single Integrator dynamics); 2. application to ground mobile robots (simulation with Differential Drive kinematics); 3. remote experiments on real robots (using Georgia Tech Robotarium online platform [3]); 4. implementation on the mobile robots in the flight arena of CentraleSupélec.

¹ CentraleSupélec is one of the most prestigious French graduate engineering schools (“Grandes Ecoles”).

Allowing students to propose their own subject of case study, during the practical work sessions, was very appreciated. In addition, it was both a source of motivation for the students and an inspiration for the pedagogical team. Among these subjects, some topics were related to sustainable development, rescue missions, collaborative games, and also inspired from Arts (e.g. artistic drone shows, artistic pattern generation [4], etc.). Indeed, Arts can be an additional motivation for students to learn engineering, more precisely Control Engineering in our teaching activities. Starting from basic artistic patterns using consensus, the students were able to propose numerous changes in the consensus algorithm, e.g. different number of agents, different communication topologies (type of graph, switches in the topology, etc.), different gains for the control law (different value and sign, time-varying gain, etc.) leading to innovative artistic patterns [5].

One example of artistic consensus is an artistic choreography of six kites performing cyclic pursuit with changes of direction and of the circle radius. The students replicated a sequence of a kite contest video (found by themselves): 1. in simulation; 2. remotely using Robotarium; 3. on mobile TurtleBot Burger vehicles in the flight arena of CentraleSupélec. Ideas for several new choreographies (e.g. inspired from synchronized swimming) appeared by mixing Multi-Agent Systems control and Arts.

Strong effort combining Arts and Engineering (both theoretical aspects and practice) allowed us to motivate our students for better understanding key concepts in consensus control of Multi-Agent Systems. Current projects focus on popularizing science (more precisely Automatic Control concepts) via Arts, developing physical intuition through dance, etc.

Acknowledgements

This work has been accomplished within the *MEECOD – "Moderniser l'Enseignement par l'Expérimentation sur la COordination de Drones"* project supported by UPSaclay (Université Paris-Saclay) and the *DAReTeach – Drone Arenas-based Remote International Teaching* project, with the support of the FACE Foundation (French-American Cultural Exchange in Education and the Arts).

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