Diploma Topics 2021-2022, AI-MAS Laboratory

Robotics

Title: Autonomous Indoor Environments Exploration

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

Description:

The main objective is to develop an autonomous exploration application for indoor environments using the Ant Robot platform in conjunction with LiDAR/RGB-D sensors. Specifically, the developed application has to create autonomously a 2D/3D map of an unknown environment. Thus, the objectives are two-fold, namely:

- develop and integrate a SLAM technique for mapping an unknown environment
- develop a planning module that leverages the current information to make decisions about the regions of the environment which either must be mapped or updated due to changes.

[1] http://wiki.ros.org/rtabmap_ros
[2] http://wiki.ros.org/hector_slam
[3] http://wiki.ros.org/explore_lite

Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS pentru implementarea proiectului.

Title:Autonomous Indoor Exploration with Semantic Augmentation

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

Description:

The main objective is to develop an autonomous exploration application for indoor environments using the Ant Robot platform in conjunction with a RealSense RGB-D sensor. Specifically, the developed application must create a 3D map of an unknown environment, identify specific objects in the constructed map and correlate the objects with their location in the map. Thus, the objectives are three-fold, namely:

- develop and integrate a SLAM 3D technique for mapping an unknown environment.
- develop a planning module that leverages the current information in order to make decisions about the regions of the environment which either must be mapped or must be updated due to changes.
- develop an automatic object recognition and location annotation technique.

[1] http://wiki.ros.org/rtabmap_ros
[2] http://wiki.ros.org/hector_slam
[3] http://wiki.ros.org/explore_lite
[4] https://github.com/AlexeyAB/darknet

Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS pentru implementarea proiectului.

Title: Conversational agent (chatbot) for health status assessment of neurological disease patients

Coordinators/Contacts: **Sl. dr. ing. Alexandru Sorici (alexandru.sorici@upb.ro)**
Cercetător dr. ing. Alex Awada (alex.awada@upb.ro)

Description:

Patients suffering from neurological conditions which affect them long term (e.g. Parkinson's Disease, Multiple Sclerosis, Recovery after a stroke incident) are in need of continuous evaluation of their physical and cognitive / emotional abilities and limitations in order to evaluate the progression or regression of the disease. Standard medical questionnaires (e.g. PHQ-9, ACTIVLIM, MDS-UPDRS) exist for assessing patient status, but these are often performed only on paper and during clinical visits.

The purpose of this research topic is to develop a ***conversational agent*** (chatbot) integrated into a ***mobile application*** which can provide a more pleasant interaction experience. The chatbot will be grounded in the content of existing medical questionnaires, but it will frame the completion of questionnaire items within a conversation which: (i) can be initiated by the chatbot, (ii) can be paused or postponed by the patient, (iii) allows for more general answering modalities (i.e. additional explanations) instead of simple selection of a questionnaire scale item.

The conversational agent is to be packaged as an Android application which can send notifications to signal the attempt to begin a conversation.

Requirements:

Basic experience in developing an Android application is a plus.

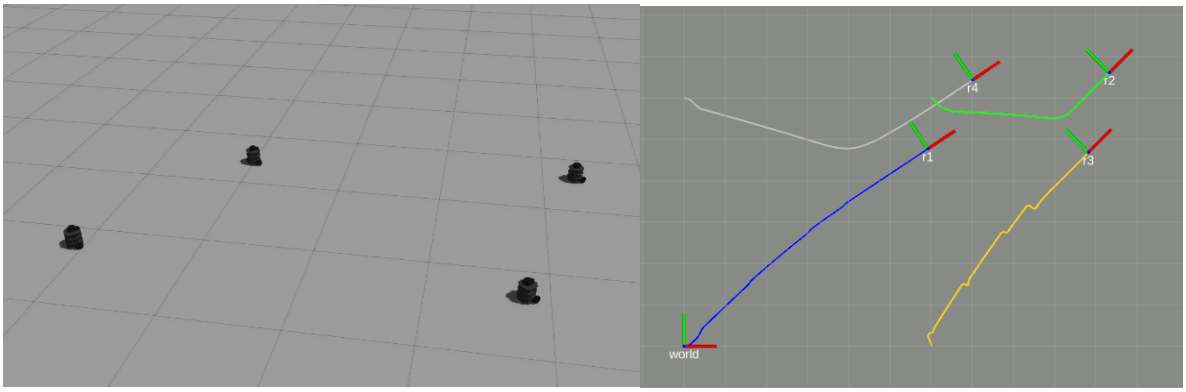
Title:MRS Open Simulator Swarm Collision Avoidance Strategies

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

Description:

In the past two decades the field of multi-robot systems has attracted the attention of many researchers from the robotics community. This attention has been motivated by the potential applications that can be achieved with a team of simple robots, including environmental exploration, search and rescue missions, surveillance operations, convergence tasks or agricultural foraging. Specifically, the field of swarm robotics focuses on systems that comprises of a large number of units, in which a collective behavior is expected to emerge from interaction among the robots, e.g. aggregation, dispersion or flocking. Central to the improvement of these collective behaviors is the ability of the individual robots to avoid collisions among themselves and with other obstacles in the environment. This project investigates the collision avoidance problem in realistic physics 3D simulated environments with real robot models using the Multi-Robot System Open Simulator.

[1] Novischi, Dan M., and Adina M. Florea. "Decentralized swarm aggregation and dispersion with inter-member collision avoidance for non-holonomic multi-robot systems." *2018 IEEE 14th International Conference on Intelligent Computer Communication and Processing (ICCP)*. IEEE, 2018.
[2] http://wiki.ros.org/gazebo_ros_pkgs
[3] http://wiki.ros.org/rviz



Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS (https://aimas.cs.pub.ro/) pentru implementarea proiectului.

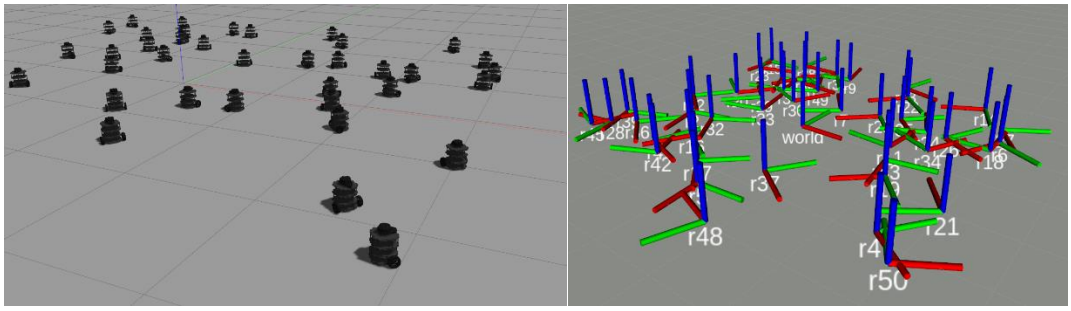
Title: MRS Open Simulator Swarm Self-Organization Strategies

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

Description:

Coordinated control of multi-robot systems has received significant attention during the last decade, with several distributed strategies and decision algorithms being developed to solve a wide variety of tasks, ranging from environmental monitoring to collective material handling. Specifically, multi-robot swarms development focuses on systems that comprises of a large number of units, in which a collective behavior is expected to emerge from local interaction among the robots designed to support the desired tasks, e.g. aggregation, dispersion, formation control or flocking. This project investigates collective strategies for self-organization in configurable swarms of mobile robots. The swarms are simulated within an existing testbed that integrates a realistic physics 3D engine, real robot models and real time visualization tools. This testbed is called Multi-Robot Systems Open Simulator and it is implemented on top of ROS and Gazebo.

[1] Novischi, Dan M., and Adina M. Florea. "Decentralized swarm aggregation and dispersion with inter-member collision avoidance for non-holonomic multi-robot systems." *2018 IEEE 14th International Conference on Intelligent Computer Communication and Processing (ICCP)*. IEEE, 2018.
[2] http://wiki.ros.org/gazebo_ros_pkgs
[3] http://wiki.ros.org/rviz



Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS (https://aimas.cs.pub.ro/) pentru implementarea proiectului.

Title: MRS Open Simulator Swarm Collective Heuristic Evaluation Metrics

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

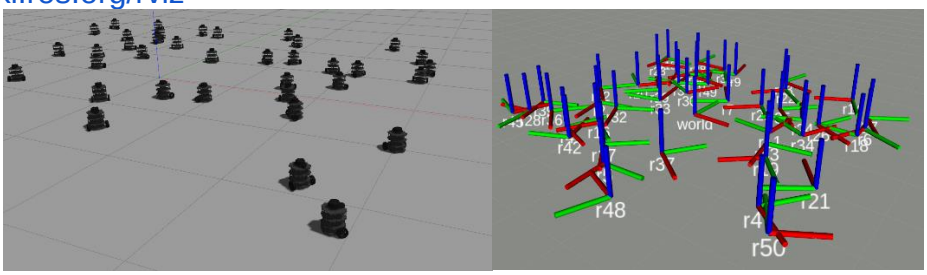
Description:

Multi-robot systems are increasingly becoming the preferred approach to many real-word applications such as search and rescue, surveillance, exploration, or agricultural foraging to name a few. In these applications teams of robots not only have to coordinate to achieve effective self-organization, but also must provide flexibility in terms of the generated formation shape structures. While such swarms can be realistically simulated in 3D setting via our Multi-Robot Systems Open Simulator, evaluating the effectiveness and efficacy of different strategies necessarily depends on the task the strategies in question are trying to solve. As such, evaluating various collective behavior strategies is both challenging and of vital importance to the successful development of multi-robot systems. This project tackles this problem with the goal of augmenting the Multi-Robot System Open Simulator with features for heuristically evaluating swarm cohesion, diffusion, center of gravity, directional accuracy, robustness, and scalability.

[1] Novischi, Dan M., and Adina M. Florea. "Decentralized swarm aggregation and dispersion with inter-member collision avoidance for non-holonomic multi-robot systems." *2018 IEEE 14th International Conference on Intelligent Computer Communication and Processing (ICCP)*. IEEE, 2018.

[2] http://wiki.ros.org/gazebo_ros_pkgs

[3] http://wiki.ros.org/rviz



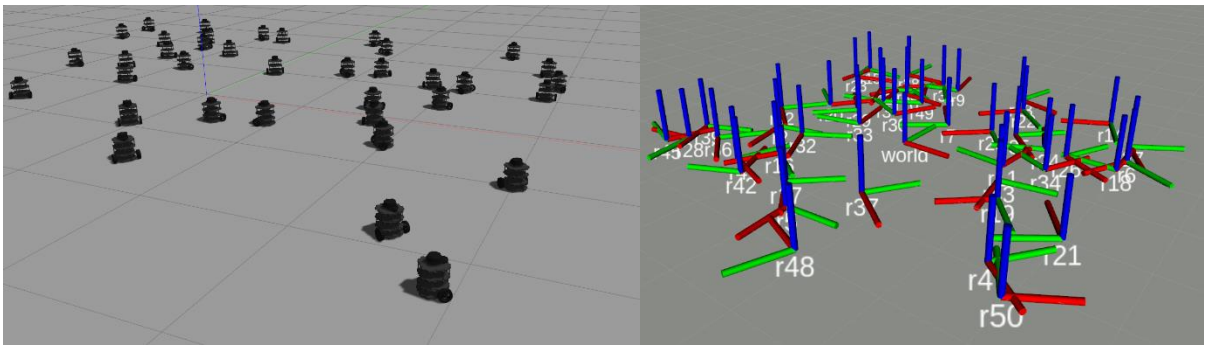
Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS (https://aimas.cs.pub.ro/) pentru implementarea proiectului.

Title: MRS Open Simulator Robot Models

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

Description:

In the past two decades the field of multi-robot systems has attracted the attention of many researchers from the robotics community. This attention has been motivated by the potential applications that can be achieved with a team of simple robots, including environmental exploration, search and rescue missions, surveillance operations, convergence tasks or agricultural foraging. Specifically, the field of swarm robotics focuses on systems that comprise of a large number of units, in which a collective behavior is expected to emerge from interaction among the robots, e.g., aggregation, dispersion or flocking. While developing such swarms is an extremely time-consuming task with prohibitive costs even for smaller swarms, our Multi-Robot System Open Simulator provides an effective way to develop such swarms in a realistic and transferable manner. Currently, our simulator provides features to easily integrate and use real robot models for various unicycle mobile robot platforms. The goal of this project is to extend the existing features such that the simulator supports Drone, car-like and omni-directional robot models in a seamlessly configurable manner.



[1] Novischi, Dan M., and Adina M. Florea. "Decentralized swarm aggregation and dispersion with inter-member collision avoidance for non-holonomic multi-robot systems." *2018 IEEE 14th International Conference on Intelligent Computer Communication and Processing (ICCP)*. IEEE, 2018.

[2] http://wiki.ros.org/gazebo_ros_pkgs

[3] http://wiki.ros.org/rviz

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Titlu: Multi-Robot Swarms Local Sensing Beacons

Coordonator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

Descriere:
Swarm-urile robotice sunt constituite dintr-o serie de roboți cu capacități cognitive reduse, care pe baza interacțiunilor locale distribuite implementează diverse comportamente emergente complexe la nivelul global al swarm-ului precum: convergenta asupra unei arii (agregare), acoperirea unei arii (dispersie), deplasare in formatii (strategii de coordonare), s.a.m.d. Interacțiunile între roboți, in acest sens, se bazează pe informații locale colectate de fiecare robot fata de robotii vecini imediati, precum: orientarea si distanta relativa. Astfel, tema își propune dezvoltarea unui sistem senzorial încorporat hardware/software pentru detecția vecinilor și colectarea informațiilor locale prin implementarea unor module de tip becon cu senzori IR și de distanța. Acest sistem va fi integrat și testat folosind platforme robotice disponibile.

[1] Turgut, Ali E., et al. "Kobot: A mobile robot designed specifically for swarm robotics research." *Middle East Technical University, Ankara, Turkey, METU-CENG-TR Tech. Rep* 5.2007 (2007).
[2] Novischi, Dan, and Adina Florea. "Ant intelligent robot: A versatile and low cost miniature mobile robot platform for swarm robotics research and education." *Proceedings of the 9th EAI International Conference on Bio-inspired Information and Communications Technologies (formerly BIONETICS)*. 2016.

Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS (https://aimas.cs.pub.ro/) pentru implementarea proiectului.

Titlu: Intelligent Robot Navigation System

Coordinator/Contact: **Sl. dr. ing. Dan Novischi (dan_marius.novischi@upb.ro)**

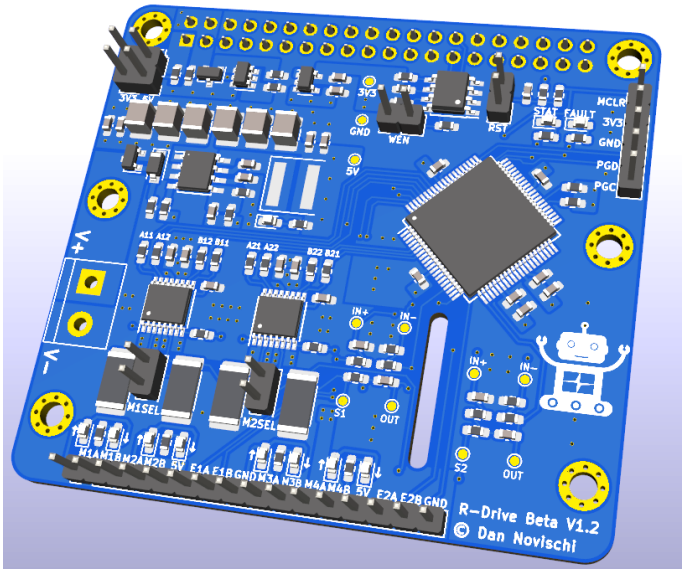
Descriere:
Proiectul își propune agumentarea sistemului R-Drive de navigatie prin introducerea facilitatilor si modulelor software adaptive pentru suportul modelelor cinematice precum: uni-ciclu (ex: segway), omni-directional (pepper robot) si bi-cicul (automobile). In cadrul proiectului se vor dezvolta urmatoarele facilitati software:

- integrare FreeRTOS si bootloader
- modulul de interfatare cu SOC-uri precum Rpi
- Integrarea modulului adaptiv de navigatie utilizând tehnici de tip hill climbing/rețele neurale
- nodul ROS pentru interacțiunea cu modulul

Dezvoltarea, testarea și validarea se va realiza utilizândz platforma AntRobot disponibilă pentru acest proiect.

[1] Novischi, Dan, and Adina Florea. "Ant intelligent robot: A versatile and low cost miniature mobile robot platform for swarm robotics research and education." *Proceedings*

of the 9th EAI International Conference on Bio-inspired Information and Communications Technologies (formerly BIONETICS). 2016.
[2] http://wiki.ros.org/ROS/Introduction
[3] https://www.freertos.org/FreeRTOS-quick-start-guide.html



Opțional: Studentul va putea utiliza resursele de calcul puternice / componente disponibile ale laboratorului AI-MAS (https://aimas.cs.pub.ro/) pentru implementarea proiectului.

Title: Dialogue Management Service supporting the Romanian language in assistive robotics scenarios

Coordinators/Contacts: **Sl. dr. ing. Alexandru Sorici (alexandru.sorici@upb.ro)**
Cercetător dr. ing. Alex Awada (alex.awada@upb.ro)

Description:
A dialogue management system, in the context of assistive robotics, is an application that models and guides a conversation carried out between a human user and a robot, by means of multiple modalities (e.g. written text, voice interaction), taking into account external cues (e.g. environment state, user fatigue or emotional state).
The purpose of this project is to develop a dialogue management service that works across different platforms and supports the Romanian language.
The service will be built in a modular, micro-service oriented architectural style, making use of existing web APIs that facilitate text-to-speech and speech-to-text processing for the Romanian language. The dialogue management service is expected to enable scriptable interaction scenarios, whereby the answers given by the robot are informed by both conversational context, as well as emotional state of the user (i.e. the response in the dialogue depends on what the user has said previously and on how he is feeling).

At the same time, the start of a dialogue can be triggered by contextual cues (e.g. the light is turned on in a room, a motion sensor is triggered), apart from direct voice interaction.

Titlu: Interactiune Multimodala om-robot

Coordonatori/Contact: **Prof. dr. ing. Irina Mocanu (irina.mocanu@upb.ro)**
Cercetător dr. ing. Alex Awada (alex.awada@upb.ro)

Descriere:

Scopul proiectului constă în realizarea unui sistem capabil să permită interacțiuni multimodale om-robot, cum ar fi interacțiunile gestuale și vocale. Se va dezvolta un sistem de recunoaștere a gesturilor pe baza analizei imaginilor RGB (sau RGB-D - imagini RGB si depth). Optional, recunoașterea gesturilor va fi portata pe robotul TurtleBot, care pentru fiecare gest va realiza o anumită comandă (de exemplu deplasare către un anumit punct - pentru comenzile robotului se vor utiliza acțiuni simple, predefinite). Pentru a permite interacțiunile vocale, un serviciu va trebuii construit folosind API-urile web existente care facilitează procesele de text-to-speech, speech-to-text si natural language understanding, pentru limba (limbile) română și / sau engleză. Este permisă integrarea unor modalități suplimentare de interacțiune între utilizator și robotul TurtleBot.

Bibliography:

1. https://news.developer.nvidia.com/hello-world-robot-responds-to-human-gestures/
2. https://arxiv.org/pdf/2007.09945v2.pdf
3. https://www.sciencedirect.com/science/article/pii/S2212827120314359
4. https://www.frontiersin.org/articles/10.3389/frobt.2021.612750/full

Number of students: 2