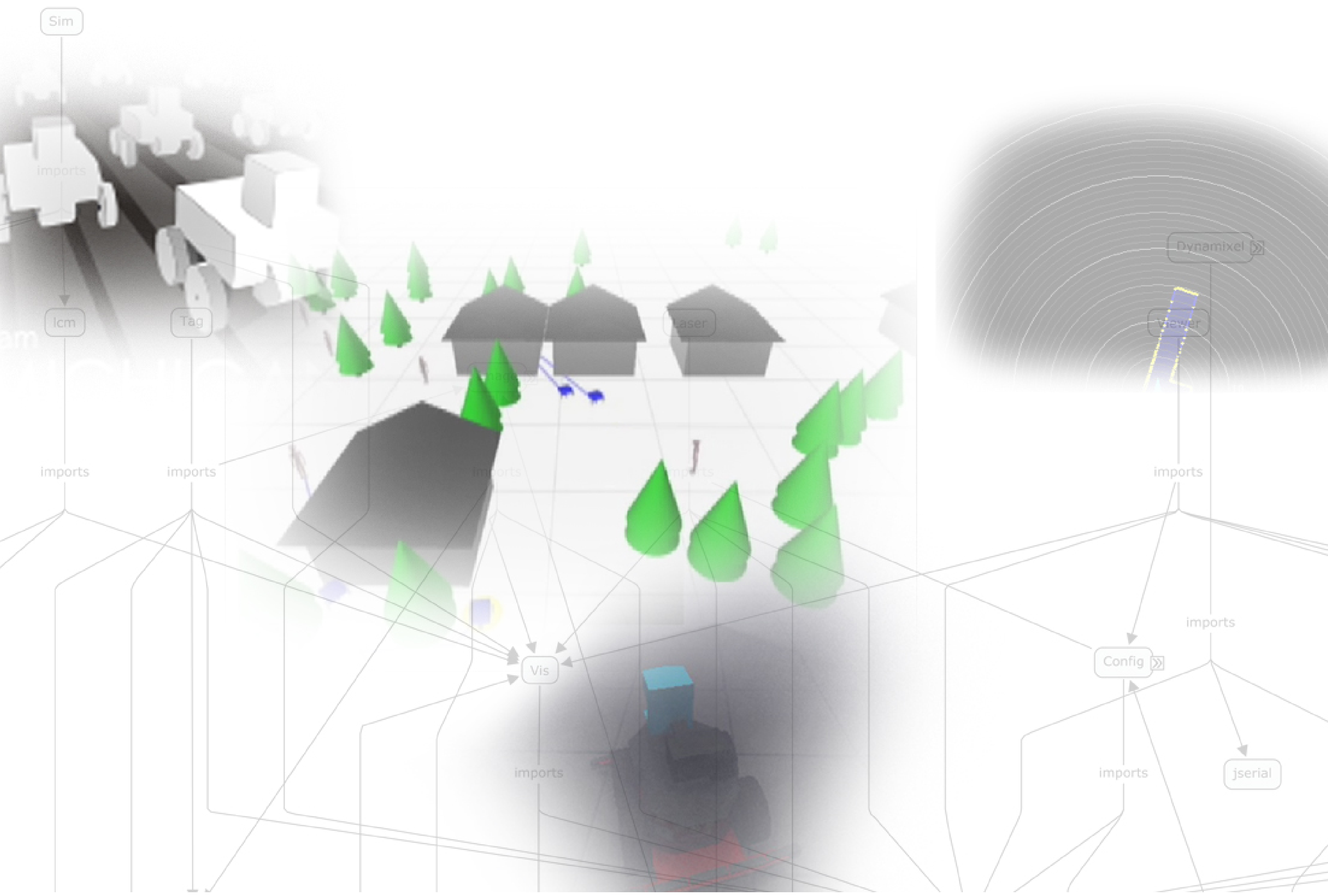
APRIL ROBOTICS LABORATORY MODULES FOR USARSIM



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April Robotics Laboratory modules for USARSim

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Abstract

The aim of this report is to exam the modules April Robotics Toolkit, and to demonstrate how these can be coupled to the USARSim environment. The April Robotics Toolkit has been used to participate in the MAGIC competition.The Toolkit contains several libraries created for robotic applications which are intended to be easy to integrate into other projects. In this paper some of the module will be used in combination with the USARSim environment to demonstrate how the libraries from the April Toolkit can be of use in USARSim.

Contents

1 Introduction

Simulation is one of the key aspects in the field of robotics. Simulation allows robotic experiments to be conducted in a safe, controlled and reproducible environment. The machinery used in the field of robotics can be expensive, and it is important that experiments can be conducted safely without endangering the equipment before using the robots in a real world environment. Circumstances in a real world environment such as rain or fog cannot always be controlled in order to create a desirable test area, whereas in a simulator such circumstances can always be customized to fill the needs of the experiment. A simulator will also have visual aides to give more insight in the events of the experiment, such as visualizations of the beams or the data of a sensor.

One such a simulator is USARSim, Unified System for Automation and Robot Simulation, which is a detailed simulator for robots and their environments [1]. USARSim is used by robotic projects such as the annual RoboCup Rescue competition, and the Virtual Manufacturing competition. Another toolkit is the April Robotics Toolkit, which contains a growing number of libraries targeted towards robotics applications [2]. These libraries are intended to be easy to integrate into existing projects. The April Robotics Toolkit has been used to participate in competitions such as the MAGIC (The Multi Autonomous Ground-robotic International Challenge) and the DARPA Grand Challenge.

This report presents a way to use the libraries from the April Toolkit in combination with the USARSim environment. The modules of the April Toolkit will be inspected, and some of the modules will be selected and will be used to combine the features of USARSim and April Toolkit, in order to demonstrate that the Toolkit offers useful libraries for the field of robotics, and that more of the modules can be used to add features to USARSim.

2 Related work

As stated before, simulation is a key aspect in the field of robotics, and one of the simulators designed for robots and their environment is USARsim (Unified System for Automation and Robot Simulation) which is based on Unreal Development technology[3]. *USARSim: a robot simulator for research and education*[3] is the work that has presented the field of robotics with USARSim, and provides its general architecture, describe examples of utilization, and provide a comprehensive overview for those who are interested in robot simulations for education, research and competitions.

The work *Towards heterogeneous robot teams for disaster mitigation: Results and Performance Metrics from RoboCup Rescue*[7] presents the results of the first annual RoboCup Rescue Virtual competition, and provides information such as the summaries of the algorithms used by the top four

[1] http://sourceforge.net/projects/usarsim/

[2] http://april.eecs.umich.edu/wiki/index.php/Download_and_Installation

[3] http://www.unrealengine.com/udk/

teams, for the readers to compare and contrast. Additionally an examination of the simulation engine is presented as well as real-world validation results.

The paper *Evaluating maps produced by urban search and rescue robots: lessons learned from RoboCup*[2] presents the map evaluation methodology developed for the Virtual Robots Rescue competition. The procedure aims to evaluate the quality of maps produced by systems making use of more than one robot with respect to factors such as usability, exploration, annotation and other aspects relevant to robots.

The April Robotics Laboratory has entered the 2010 MAGIC competition with Team Michigan. They have created a 14-robot team designed to perform urban reconnaissance missions that has been victorious in the MAGIC 2010 competition. The paper *Progress towards multi-robot reconnaissance and the MAGIC 2010 Competition*[6] describes the team of robots, as well as a variety of autonomous systems which require minimal human effort to control a considerable number of autonomously exploring robots.

The paper *Variable reordering strategies for SLAM*[1] describes how the April Robotics lab evaluated the performance of various reordering techniques on benchmark SLAM data sets and provide definitive recommendations based on their results.

3 RoboCup Rescue, UvARescue

RoboCupRescue project is an international cooperation to promote research and development, and the goal of the RoboCup Rescue Simulation League is to build a Multi-Agent community for rescue operations in simulated environments. The UvaRescue has published numerous work such as *Evaluating maps produced by urban search and rescue robots: lessons learned from RoboCup*[2] and *"Towards heterogeneous robot teams for disaster mitigation: Results and Performance Metrics from RoboCup Rescue"*[2]. The University of Amsterdam has participated in the Rescue League since 2003, both in Germany and Italy, and has remotely participated in the Rescue Middle Earth competition. The UvA Rescue team has also participated in the Virtual Robot competition in Bremen, and have received a prize for their mapping algorithm. After reaching the finals in Hannover in the German Open 2008, the UvARescue team joined forces with Oxford in the Amsterdam Oxford Joint Rescue Forces. With this team they have been present at Suzhou, RoboCup 2008, and remotely present in Salvador, the Latino American Open 2008. In 2009 several prizes were won at the German Open, the World Cup and the Interleague Challenge. In 2010 to 2012 the team had participated at the Iran Open competition, where they have received the USARsim Development prize, 3rd prize and Best scientific presentation prize respectively.

4 April Robotics Laboratory

The April Robotics Laboratory at the University of Michigan investigates Autonomy, Perception, Robotics, Interfaces, and Learning, and is part of the

Computer Science and Engineering department, and has published a substantial amount of articles and work in the field of robotics. For example The April Robotics laboratory has published *A High-rate, Heterogeneous Data Set from the DARPA Urban Challenge*[5], which describes data sets collected during the 2007 DARPA Urban challenge, to be of use to the autonomous vehicle community. With team Michigan, the April Robotics Laboratory has entered the MAGIC 2010 Competition, winning first prize, and have described their experiences in the paper *Progress towards multi-robot reconnaissance and the MAGIC 2010 Competition*[6].

The April Robotics lab has also published software for others to use, for example *LCM: Lightweight Communications and Marshalling*[4], which describes a library for message passing and data marshalling, with the goal to simplify the development of low-latency message systems, especially for real-time robotics research applications. LCM can prove very useful to existing projects that involves sending and receiving messages at certain levels.

Additionally, they have created software to use in research in the field of robotics, namely the April Robotics Tookit, which contains numerous libraries and modules targeted towards robotics applications. The libraries and modules are intended to be easily integrated into other existing projects.

5 Objective

The objective of this project is to examine the modules of the April Robotics Toolkit, and to observe which of these modules can be relevant to the Robocup Rescue. Additionally the architecture from the Toolkit will be examined, and how it can be coupled to other platforms, such as USARSim. Ultimately a bridge must be built between the modules of the April Toolkit, and the USARSim environment.

5.1 Research

Research has been conducted to examine the structure of the April Robotics Toolkit in order to obtain more insights of the working of the different modules. The Toolkit primarily makes use of LCM to transmit messages between its modules, and integrating any part into an existing project can best be approached by using LCM-channels. The connections between the modules are illustrated in Appendix A. Additionally, all files in the modules have been looked at to examine the content and the connections of the modules. A summary of the examination of the files can be found in Appendix B. The Toolkit contains useful packages that can be relevant for the Robocup Rescue such as April Tag, which is a visual fiducial system using 2D barcodes. Another useful package are the plugins for LCM that can visualize sensor data. The toolkit also features several utilities that can be useful in general, such as the KeyboardGamepad, which allows sending keystrokes to the program using LCM.

6 Connecting April and USARSim

To demonstrate how the April Robotics Tookit can be used in the USARSim environment, a program UsarSimTransmit has been written in C# to connect with USARSim and to spawn a robot of the class P3AT. The USARSim environment that has been used is the RoboCup2012 Tryouts map. The P3AT has several sensors connected to it one of which is a range scanner module which captures information for the environment. The information that is captured by the sensors of the robot is then translated into LCM format and is then sent out to an LCM channel. The data in LCM format can now be interpreted by other modules in the April Robotics Toolkit. The P3AT in the test environment is shown in Figure 1.

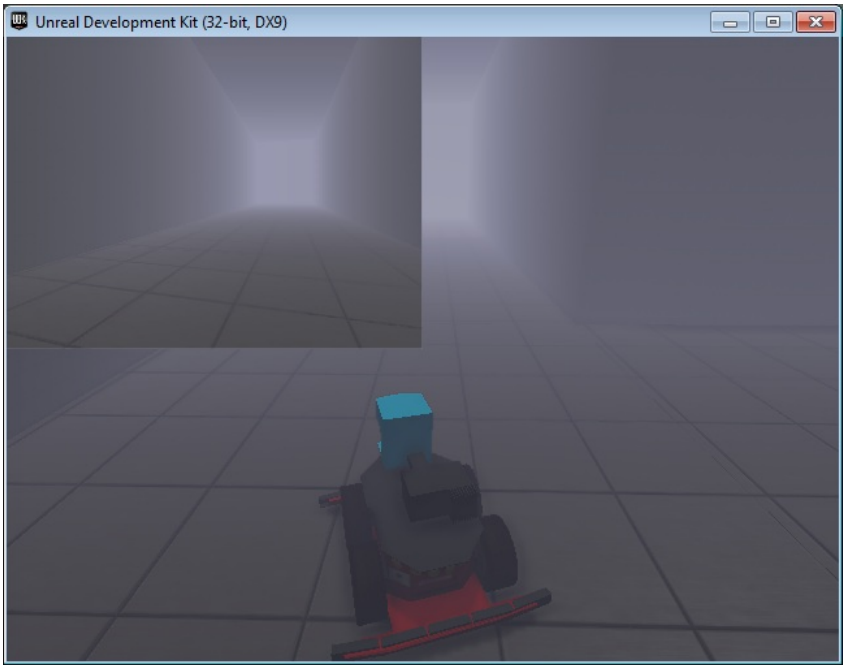

Figure 1: The P3AT agent spawned in USARSim environment, sending to LCM channel.

6.1 Spy module

The LCM Spy module from the April Robotics Tookit can monitor all channels of LCM that are being broad casted on the system, and can be useful for examining the LCM messages that are being sent and received within a large project. The LCM spy module is shown in Figure 2.

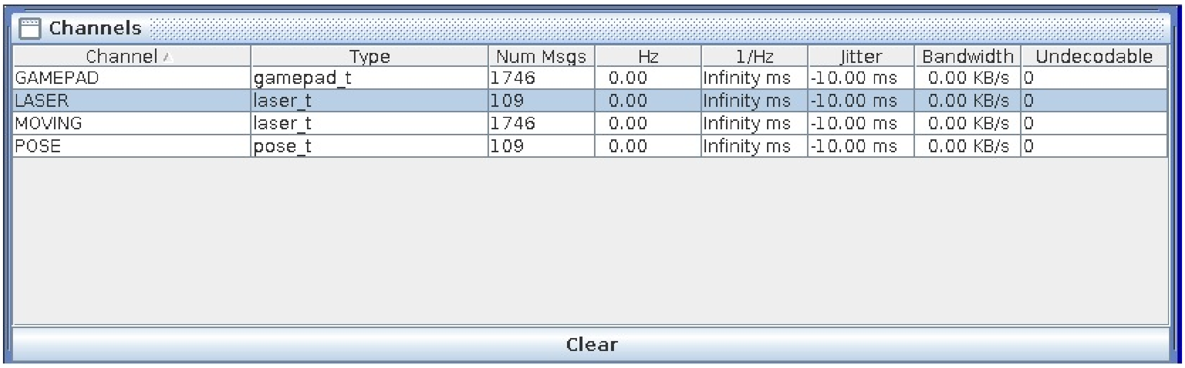

Figure 2: The LCM spy monitoring the LCM channels being broad casted.

Monitoring the LCM channels can give more insight in the situation and give the user more information on what is going on with the sensor data. In complex projects it can be very difficult to keep track of all the messages that are being sent and received during an experiment. The inspection of a LCM channel is shown in Figure 3.

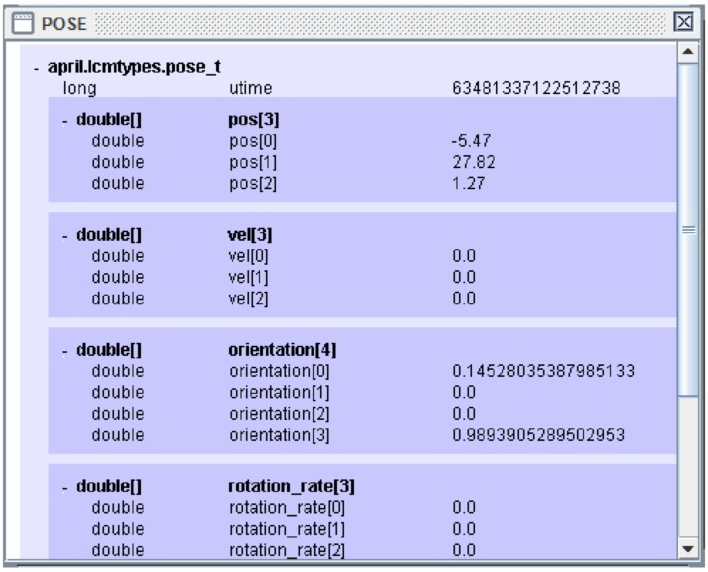

Figure 3: Details of a monitored LCM channel.

The LCM Spy module also features several plugins that add functionality to the module, one of which is the LCM Spy Laser module, which can be used to visualize the data of a laser sensor in the simulator. The plugin showing a visualization of laser data is shown in Figure 4.

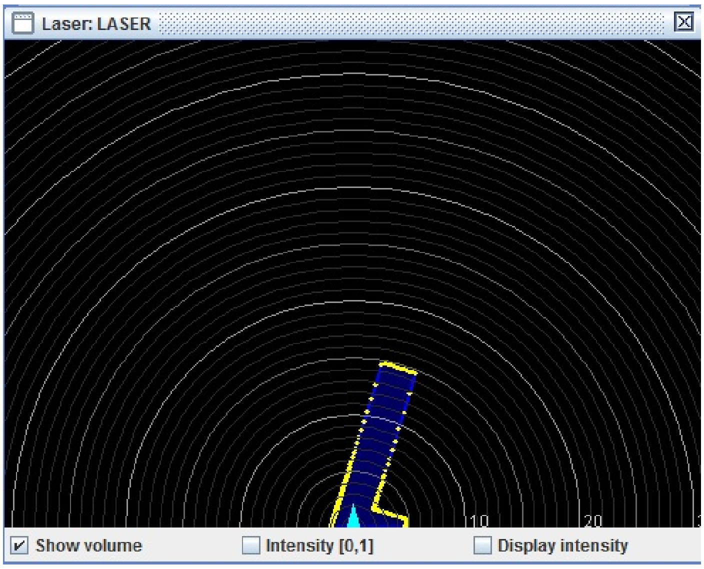

Figure 4: Visualization of sensor data in UsarSim.

The LCM module also comes with its own Logger, which is capable of recording all of the channels and data that have been sent in a session. Additionally, the module also has a Logplayer, which allows the playback of sessions, giving the recorded data, but also sending out the LCM messages that were sent during the session. This enables users to replay the simulation real time, by playing a logfile and letting the simulator receive the LCM messages. This way sessions are easily repeated and investigated. Figure 5demonstrates how the Logger and LogPlayer can be used. Since the Logger captures all LCM messages, modules can be omitted while the LogPlayer transmits over the LCM channels.

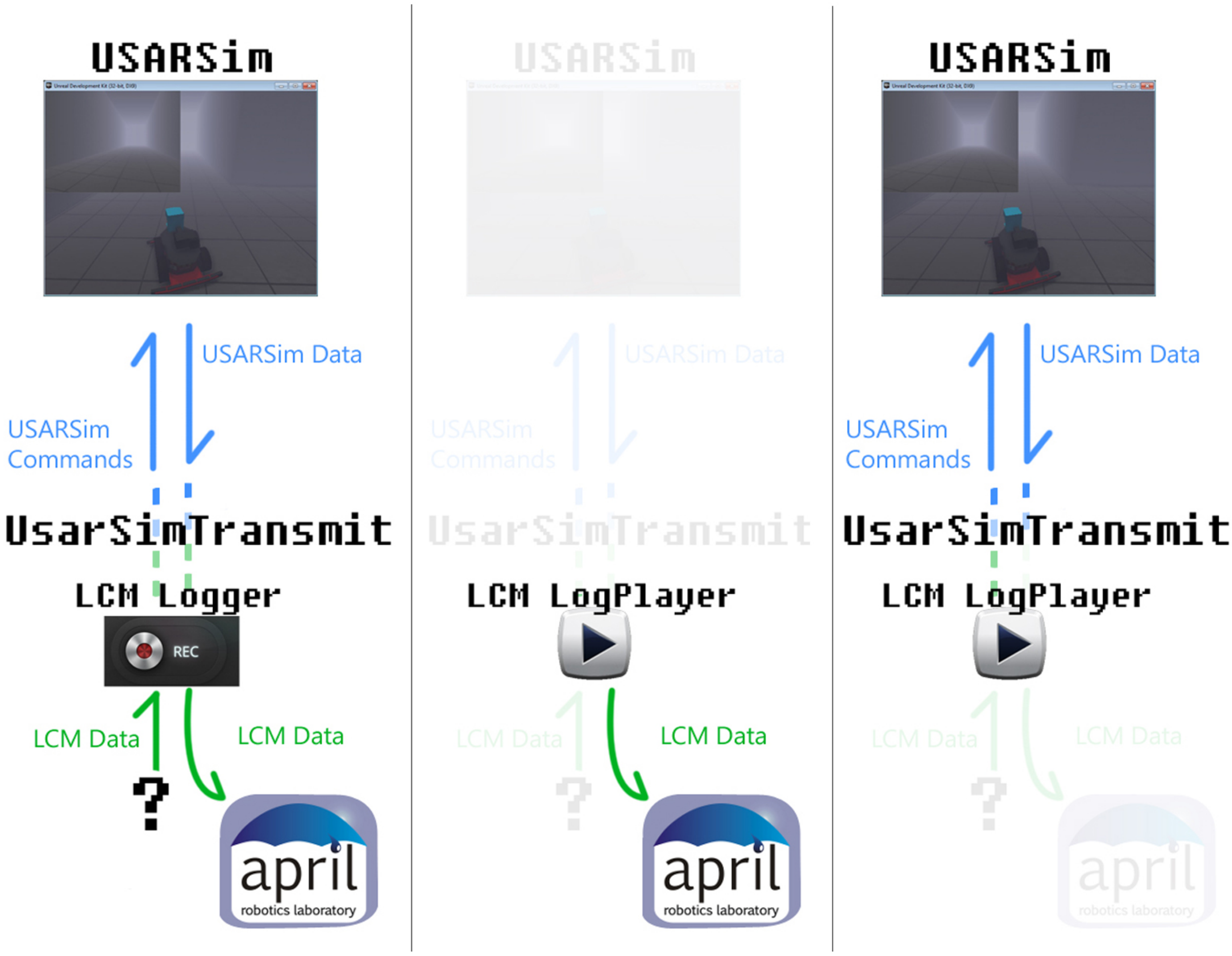

Figure 5: Demonstration of how the LCM logger and LogPlayer can be used. The left pane shows that the LCM logger captures all LCM messages. The middle pane shows how the LogPlayer can be used to simulate the session in a April module, and the right pane shows how the session can be simulate the session in USARSim.

6.2 Controlling USARSim

The connection between LCM from the April Robotics Toolkit and USARSim has so far been used to read data and information fro the USARSim environment, and not yet to control variables in USARSim. To do this a utility from the April Robotics Toolkit has been slightly modified to demonstrate how one could manipulate the P3AT robot in the USARSim environment. The utility module from the toolkit that has been used is KeyboardGamepad, which as the name suggests enables users to use a keyboard as a gamepad. The module was modified so it would send messages to a certain channel whenever the arrow keys of the keyboard are pressed. UsarSimTransmit has been adjusted to listen to this LCM channel and send a message to the USARSim engine accordingly to the message it received, making the P3AT respond to the keystrokes of the arrow keys. The P3AT in USARSim is now controllable through UsarSimTransmit using LCM. Because the module uses LCM to transmit movement commands, the signal of KeyboardGamepad can be recorded by the LCM Logger, making movements of the agent completely repeatable.

7 Results

A bridge has been created between the USARSim environment, and the modules of the April Robotics Tookit, named UsarSimTransmit. Using the April Tookits LCM, a library for message sending, a connection has been made for USARSim to send data that can then be used by other April modules, such as the LCM spy, LCM Laser plugin, LCM Logger. Additionally, a connection has been made between Aprils KeyboardGamepad and the UsarSimTransmit to establish a form of control of the agents in USARSim. A diagram of the connected modules, with LCM Spy and LaserPlugin as example, is shown in Figure 6. Note that the LCM Spy will also capture the LCM data of the KeyboardGamepad, as it monitors all the LCM data on the system.

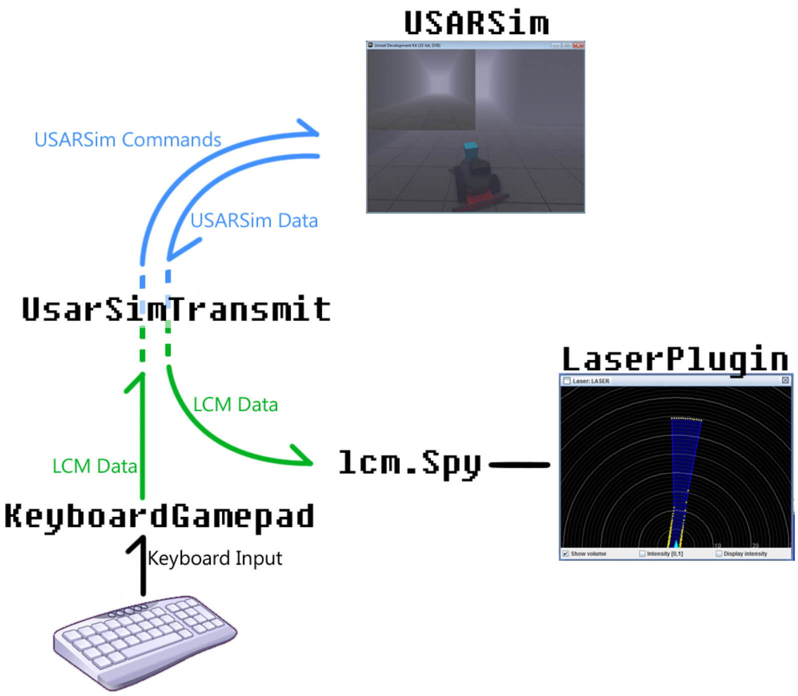

Figure 6: Diagram of the connected modules.

8 Conclusion

In this work it has been demonstrated that several modules from the April Robotics Toolkit have successfully been used in combination with the USARSim environment. It is now possible for a robot in USARSim to send his sensor data over an LCM channel, in the correct format, making it possible to let the sensor data be used by more modules from the April Toolkit. Users are now able to monitor the sensor data from USARSim in modules such as the LCM Spy, and visualize it with the plugins available, the laser and video plugins. Furthermore, It has also been made possible to control agents in USARSim with the keyboard by using a Keyboard Utility module from the Toolkit that interprets keystrokes and sends messages through an LCM channel for the UsarSimTransmit to receive.

9 Discussion and future work

Future work would entail coupling various more modules to the USARSim environment such as the April Tag module for multi-bot teams, or the April Toolkits line and feature recognition, and using the visualizer in combination agents, as shown in Figure 7. Additionally, features of LCM can also be expanded upon, such as the UPD Multicast for transmitting across systems.

Figure 7: The April Toolkits visualizer in combination with a robot. Image from *http://april.eecs.umich.edu/magic/*

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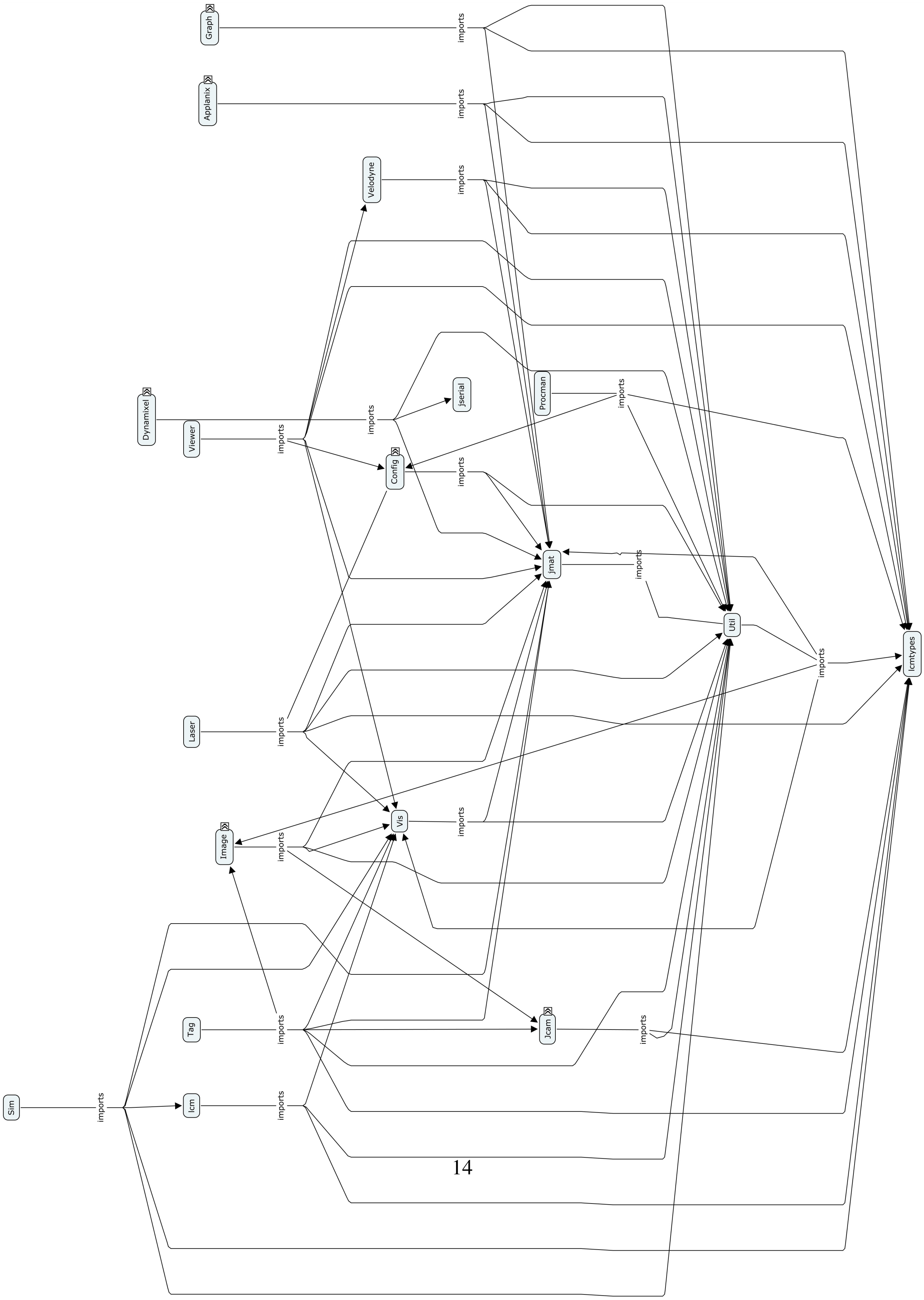
Graph
Applanix
Velodyne
Dynamixel
Viewer
jserial
Procman
Config
jmat
Util
lcmtypes
Laser
Vis
Image
Tag
Jcam
Sim
lcm
imports

B

Applanix
A module containing files for configuring data rate, and categorize messages.
Config
Module for reading config files
Dynamixel
Contains bus and servo files. The dynamixel GUI gives information about the different Servo classes, and calculates certain parameters.
Graph
A package for a certain data type, Graph. Contains components such as nodes and edges, and includes modules for finding the best path for the Graphs.
Image
Module for image manipulating and recognition. Contains features such as gradients, feature recognition, colorize.
Jcam
Module for the use of a camera.
Jmat
Holds mathematical modules and geometrical representations.
Laser
Module for a laser sensor. Includes files for scan matching, hill climbing algorithm for GridMap objects, and line features.
Lcm
Module for the LCM that the April Toolkit uses. Includes the Video and LaserPlugin.
Lcmtypes
The different types of LCM messages/objects.
Procman
ProcMan is a process manager for Java. A config file specifies which processes should be managed, and the policy for when to run these, and what to do if they fail.
Sim
Contains a small simulator including several basic objects.
Tag
Module for 2D Tag recognition.
Util
General utilities such as the KeyboardGamepad.
Velodyne
Module for the Velodybe laser. Includes parser for data from a Velodyne laser scanner.
Viewer
A viewer applet designed to be used/integrated into other panels/applets
Vis
Visualizing module. Includes examples, numerous shape objects and panel components.