GOLOG++ Hits the (Right) Spot: Interfacing Golog with a Quadruped Rescue Robot for High-Level Missions

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Abstract: The Robot Operating System has become the de facto standard middleware in the robotics field. ROS offers a large variety of state-of-the-art algorithms and solutions for robotics problems ranging from localisation to manipulator control. For most robot systems available on the market, a ROS or ROS2 driver exists. When it comes to high-level control, relatively few packages and approaches exist inside the ROS ecosystem. In this paper, we report on our efforts to integrate the well-known action language GOLOG with ROS2 in order to enable rescue missions for our Boston Dynamic Spot robot in the RoboCup Rescue scenario.

1 INTRODUCTION

The Robot Operating System (ROS and ROS2 (see e.g. (Maruyama et al., 2016))), has become the de facto standard middleware in the robotics field. With initiatives like ROS-Industrial[1] industrial robot manufacturers acknowledge the potential of ROS and ROS2, respectively, as a robot middleware. The Github repository "*vmayoral/ros-robotics-companies*"[2] mentions more than 900 companies that make use of ROS. ROS offers a large variety of state-of-the-art algorithms and solutions for robotics problems ranging from localisation to manipulator control. For most robot systems available on the market, a ROS or ROS2 driver exists.

In contrast to this, the variety of ROS packages for high-level missions of mobile autonomous robots is quite limited. There exists some ROS packages for formulating finite state machines such as `RAFCON` (Brunner et al., 2016), the package `behaviour_tree` (Segura-Muros and Fernández-Olivares, 2017) for behaviour trees, or the PDDL-based `rosplan` package (Cashmore et al., 2015). While it is not an official ROS package, another PDDL-based planning package is available, which interfaces the production system CLIPS with ROS (Niemueller et al., 2019).

On the other hand, there are many control languages from the autonomous agent or cognitive robotics community, but they have not yet found their ways into the ROS ecosystem in numbers.

In this paper, we report on our efforts to integrate the well-known action language GOLOG (Levesque et al., 1997) with ROS2 in order to enable rescue missions for our Boston Dynamic Spot robot in the RoboCup Rescue scenario (Kitano and Tadokoro, 2001).

In order to solve the problems proposed in the RoboCup rescue scenario, our Spot is equipped with additional sensors and a manipulator. We developed a ROS2 driver for the Spot in cooperation with the Boston Dynamic AI Institute.[3] A paper describing the features of the ROS2 Spot driver is in preparation.

Our GOLOG/ROS2 integration is based on our previous work on `golog++` (Mataré et al., 2021; Kirsch et al., 2020). The contribution in this paper is two-fold. We describe the `golog++`/ROS2 integration in detail showing how high-level actions can be executed as ROS action servers. Also as a running example, we show how the famous blocksworld task is solved by Spot with our manipulator using GOLOG and ROS2 deploying a decision-theoretic planning approach.

In the next section, we discuss related work in the area of action-based high-level and planning ap-

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[1] https://rosindustrial.org/
[2] https://github.com/vmayoral/ros-robotics-companies

[3] See https://github.com/bdaiinstitute/spot_ros2 for the GitHub Repo.

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proaches for mobile robot and in particular related work about GOLOG. The `golog++` system is outlined in Section 3. In Section 4, we make a walk-through the blocksworld program, before we give the details of integrating `golog++` with ROS2 in Section 5. We conclude with Section 6.

2 RELATED WORK

Related to this work is also the rich body of papers about different extensions of the original GOLOG language (Levesque et al., 1997). With its original semantics based on the Situation Calculus (McCarthy, 1963), GOLOG is well-suited for modelling behaviours in dynamically changing worlds. It has been deployed in a wide variety of tasks ranging from semantic web applications (McIlraith and Son, 2001) or domestic robot applications (Schiffer et al., 2012) to robotic soccer (eg. (Ferrein et al., 2005)). Extensions include to deal with exogenous events, concurrency, allow for decision-theoretic planning, or continuous changes in the world, to name but a few (see, for instance, (De Giacomo et al., 2009; Boutilier et al., 2000) for further details). While classical implementations of GOLOG are based on Prolog, there have also been attempts to utilize alternative interpreters, (eg. (Eckstein and Steinbauer, 2020)).

Outside of the GOLOG community, we see more diverse approaches to high-level interfacing. The Semantic Robot Description Language (SRDL) (Kunze et al., 2011) implements a framework that describes a robot platform with its components, and how they can be used to realize certain actions. As such, it serves a different purpose, namely mapping an abstract action concept to a realization strategy on a particular robot platform. To the framework we envision here, actions are opaque units, so a system like SRDL could be used as an action execution backend.

PRS/OpenPRS (Ingrand et al., 1996) and the ecosystem around them are worth noting because they also serve the purpose of a high-level control language, but found much wider use than any GOLOG dialect. However PRS does not set itself apart through better theoretical foundations or through greater expressivity. The issue where PRS clearly has the lead on any GOLOG dialect is usability, developer support, integration, i.e. *tool support* in general.

The same applies to the C-Language Integrated Programming System (CLIPS, cf. (Wygant, 1989)). From a theoretical point of view, the language should be less expressive and less practical for high-level control application than GOLOG. But nonetheless, it is used much more widely[4]. While some of CLIPS' lead on GOLOG could be explained by the more general, rule-based language paradigm, its clear advantages are still a coherent language specification and well-designed, stable C/C++ bindings.

3 GOLOG++

3.1 System Overview

`golog++` is a framework designed for the execution of the action-based logic language GOLOG on real robots. It focuses on enhancing usability and platform interfacing by addressing three key global system concerns: the representation of a GOLOG program, both static and runtime semantics, and acting/sensing functionalities.

`golog++` defines a specific syntax and comes with a parser, which transforms the agent program code into a metamodel implemented in C++ (Mataré et al., 2021). This metamodel serves both, for keeping a static representation of the program and for storing the program state while executing a program. Figure 1 gives an overview of the system architecture. The static part (shown in blue in Figure 1) consists of the parser and the static metamodel. As one can see from the figure, the front-end in blue is completely separated from the semantic backend part in the architecture. This was one of the design goals of `golog++`, as previous implementations of GOLOG in Prolog were mixing up implementation details of the interpreter with the GOLOG language. This also has the advantage that the execution model of `golog++` can be changed in the background without the need to modify the GOLOG programs. Currently, for the backend implementation, READYLOG (Ferrein and Lakemeyer, 2008) is deployed. To facilitate its functionality, `golog++` embeds the *eclipse-clp* interpreter (Schimpf and Shen, 2012), loads READYLOG and uses its *Semantics* for runtime implementation. The *ReadylogSemantics* creates *Transitions*, and once a legal transition is identified, it is then passed to the *PlatformBackend*, which specifically handles acting and sensing tasks.

`golog++` provides both a ROS1 and a ROS2 platform backend for executing actions on real robots. During the execution of an agent the *ExecutionContext* will inform the *RosPlatformBackend*, when an action has to be executed. The *RosPlatformBackend*

[4]See also 418 questions tagged "clips" on stackoverflow (stackoverflow.com/questions/tagged/clips) vs. 2 questions tagged "golog" (stackoverflow.com/questions/tagged/golog).

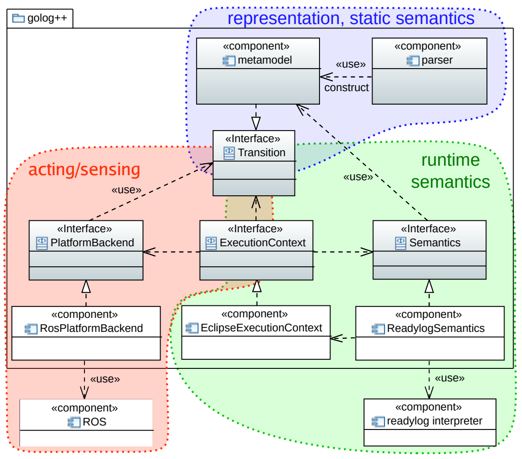

golog++
representation, static semantics
«component» metamodel
«component» parser
«use»
construct
«Interface» Transition
acting/sensing
«use»
runtime semantics
«use»
«Interface» PlatformBackend
«Interface» ExecutionContext
«Interface» Semantics
«component» RosPlatformBackend
«component» EclipseExecutionContext
«component» ReadylogSemantics
«use»
«use»
«component» ROS
«component» readylog interpreter

Figure 1: System architecture of the Framework golog++.

```
  during(grab(banana)) {
    say("Trying␣to␣grab␣banana.");
} on_fail {
    say("Failed␣to␣grab␣banana.");
} on_cancel {
    say("Grabbing␣attempt␣cancelled.");
}
```

Figure 2: Concurrent tasks.

accepts the call from the *ExecutionContext*, executes the action and responds with the outcome and an optional result.

3.2 Language Constructs

golog++ contains imperative instructions common to classical programming languages and to GOLOG dialects. Actions in golog++ are imperative statements that can be executed within a *while-loop*, a *conditional branch*, and within a *concurrent* block to handle multiple imperative branches in parallel. They can also be executed within an ordinary code block, both asynchronously and synchronously.

An action be can executed concurrent, and its outcome and status can trigger reactions such as a *succeed*, *failed* and *cancel* case. This capability can be used to create finite automata with golog++. See Figure 2 for an example.

Two instructions for nondeterminism are foreseen that are intended to be used within a planning instruction block, where they will be resolved in such a way that the entire block becomes executable. One instruction involves non-deterministic choice over an imperative statement, while the other involves selecting an argument for a given code block, for instance, as an argument in an action call.

Using the `test(b)` instruction, the agent will halt until the boolean expression *b* evaluates to true. When combined with an *exogenous event* that can set a

```
exog_action
  order_received(string what,number id){
mapping:
    "OrderInterface" {
        order_name = what,
        order_id = id
    }
effect:
    pending_order(id) = what;
}
```

Figure 3: Exogeneous action exmaple.

```
symbol domain block = {a, b, c}
symbol domain location =
               block | {t1, t2, t3}

location fluent loc(block x) {
initially:
        (a) = t1;
        (b) = t2;
        (c) = t3;
}
```

Figure 4: Location fluent.

boolean within its `effect`, this `test(...)` instruction can effectively control the execution of an action within a `concurrent` branch by causing a block in the program flow. See Figure 3 for an example from a logistic scenario, where the robot waits for an external order, which is beyond its own control, is being received.

4 THE BLOCKSWORLD EXAMPLE

The Basic Action Theory (BAT) outlines the relevant subjects in the world along with the actions available to a robot, including their preconditions and effects. It specifies the preconditions necessary for their execution and describes how these actions affect the world. In the following we outline the BAT for the blocksworld scenario. The task for the robot is to stack three blocks that are laid out in front of it in any order to a tower, where the blue block is on top, then comes the green block, and the red block is at the bottom.

First, we define the relevant fluents. In our case only the location of the blocks *a, b, c* (Figure 4). To define the blocks, golog++ offers a domain which is a typified set of values that can be used to restrict the possible arguments of an action or a fluent. With a `compound` list, elements can be iterated together using the `pick` statement. The elements `t1, t2, t3` are utilized for locations on the table, facilitating easier control of the manipulator. The fluent `loc` evaluates the current location of a specified block and establishes the initial situation. The initial configuration of `loc` can be altered prior to executing the planner.

This can be accomplished through active/passive

```
action update_block_pose(block x) {
senses:
    loc_response() =
     sense_result("/get_block_pose");

mapping:
   "/get_block_pose" {
      block = x
   }

effect:
   loc(x) = sym_to_loc(loc_response());
}
```

(a) Active sensing action.

```
action stack(block x, location y) {
precondition:
          x != y
        & loc(x) != y
        & (!exists(block z) loc(z) == x)
        & (!exists(block z) loc(z) == y)
mapping:
        "/stack" {
                block = x,
                location = y
        }
effect:
        loc(x) = y;
}
```

(b) Stack Action.

Figure 5: Examples of actions in the blocksworld scenario.

sensing actions. In our *blocksworld* scenario, we opt for an active sensing action to update the location of the blocks on the table before creating an action sequence.

Thus, the initial location of the blocks is adaptable. The action `update_block_pose()` (Figure 5a) takes a block as an argument and has no preconditions. Within the **`senses`** field, one single sensing result can be provided, allowing for a single assignment instruction.

Each active sensing result is generated by an exog. function with an argument, mapping to the low-level action that returns the result. On the right side of the assignment, we utilize the `exog_function sense_result()` with an argument leading to a ROS2 action. On the left, side we store the outcome of the low-level action in a temporary fluent. The effect updates the location of the block to our fluent `loc()` after converting to the symbol to location type (Figure 6).

The **`mapping`** specifies the actual action that should be triggered in the platform backend to execute a given action, along with how its arguments should be passed on (Figure 5b). The action `stack(x, y)` (Figure 5b) accepts arguments of the **`domain`**, namely `location` and `block`. The precondition is defined by an arbitrary Boolean formula that determines when the action becomes executable, such as when a block can be placed in a specific location.

In the **`mapping`** field, the name `"/stack"` directs the platform backend to a ROS2 action, utilizing the arguments of `block x` and `location y` as parameters to perform the low-level instructions for the manipulator. The **`effect`** assigns the updated location of `block x`.

```
symbol exog_function
    sense_result(string ros_action_name);

symbol fluent loc_response() {
initially:
        () = a;
}

location function
    sym_to_loc(symbol sym) = sym
```

Figure 6: Function for handling sensing results.

The main procedure is shown in Figure 7. Both imperative and declarative instructions for planning are employed within the program's procedures. Every `golog++` agent starts in the **`procedure`** `main(){...}` and can invoke or branch to other procedures using the concurrent instruction.

An action can be executed with the **`start`**`(...)` statement for asynchronous execution and with **`end`**`(...)` defining when the action has to finish. With **`during`**`(...)` construct concurrent tasks are also possible and enable error handling to react on a failed or cancelled action.

Once an action is executed, it can fail. During online execution the program will block if an impossible instruction is encountered whereas during *offline planning*, the search will backtrack until all possibilities have been exhausted.

The **`solve`**`(h, f){...}` statement finds executable choices for all nondeterminism within the imperative code that results in the highest cumulative reward function *f*. Thereby the search depth is limited to the horizon *h*. The nondeterminism is realised by the statements **`choose`**`{...}` selecting one of the given statements inside that block and **`pick`**`(...)` to choose an argument for the given imperative statements like actions.

5 INTERFACING GOLOG++ WITH SPOT

To solve the *blocksworld* with a real robot, low-level actions have to be implemented. The robot should initially approach the table, utilise its sensors to identify the locations of the blocks, and finally, employ the manipulator to pick up and place the blocks. In order to execute actions using `golog++`, it is necessary to interface low-level implementations, such as ROS2 actions and services, with the *RosPlatformBackend* (inside the red area of acting/sensing in the architecture overview shown in Figure 1).

```
bool function goal() =
  loc(b) == a & loc(c) == b

number function reward() =
  if (goal()) 100
  else -1

procedure main() {

   update_block_pose(a);
   update_block_pose(b);
   update_block_pose(c);

   start(navigateToFrame("target"));
   setManipulatorJoints(0, 36, -84, 0, -60, 90);
   end(navigateToFrame("target"));

   solve(8, reward())
    while (!goal())
           pick (block x in {a, b, c})
              pick(location y in {t1, t2, t3, a, b, c})
                 stack(x, y);

   setManipulatorJoints(0, 15, -130, 0, 55, 90);
   setManipulatorJoints(0, -105, -148, 0, -60, 90);
}
```

Figure 7: *The Main Procedure of our blocksworld agent.*

The Spot ROS2 driver provides all functions of Spot by topics, services, and actions and can be directly connected with the *RosPlatformBackend*. However, for the *blocksworld*, additional actions are necessary such as detecting the location of the blocks and controlling the manipulator.

To detect the blocks and approach the table, we have implemented ROS2 services and actions to detect AR tags positioned on both the blocks and the table. The manipulator, a Kinova Gen3, is controlled using the ROS *MoveIt* package and compound actions and services to execute a `stack(x,y)` action, which provides the ability to place a block at a specific location.

The purpose of the Spot ROS2 driver is to map the functionalities accessible via the Spot SDK/API to ROS2 functionalities as actions, services and topics. Thereby the driver is represented as a ROS2 node, an executable process, that is able to communicate with different nodes, like a `golog++` agent. For instance, the Spot ROS2 driver launches a service server for *stand* and *sit*. Upon request, it creates a message filled with instructions for commanding Spot to stand up or sit down, sends the message, and waits for a reply.

The Spot SDK offers access to every function that can be executed via the operator tablet that comes with the robot over a Python or C++ API. Notably, there is no complete control over all functions, including access to motors. Instead, multiple services are running internally, which can be accessed over a LAN or WiFi connection. When establishing a connection with Spot, *protobuf* messages has to be generated and sent to Spot via a client/server model, using its SDK. Using the ROS2 driver eliminates the need to learn the intricacies of the Spot SDK and reduces the effort required to utilize other ROS2 packages.

The *RosPlatformBackend*

The *RosPlatformBackend* is a ROS2 package which contains a node to load a `golog++` program. To execute low-level actions triggered by the `golog++` agent program, this node has to be modified to establish a connection between them. `golog++` defines, with the *PlatformBackend* as an abstract class, how an action has to be executed and which functions require a real implementation when executing on a real robot.

When the agent is executed and it decides that a certain action has to be executed, a function `execute_activity()` is called. This function passes an *activity* containing the mapping as unique name and possible arguments used for parameterization of the action. Once an action is executed, `golog++` waits for the outcome. When the action is completed, a function must be called to inform the agent if the action either *SUCCEEDED*, *FAILED* or was *CANCELLED*. When passing this outcome, it is possible to pass one value from the low-level action as sensing result: a *string*, *int*, *bool* or *float*.

Exogenous event are incidents that occur within the robot's environment, and the agent can to react on those event. A ROS2 message on a *topic* that triggers the exogenous event inside the agent can be filled with parameters. Those parameters can be converted to `golog++` values and used to set fluents in the `effects` of the **`exog_action`**.

To enhance the usability of the interface and reduce boilerplate code, the *RosPlatformBackend* defines *Action-*/ *Service-* and *ExogManager* as template-classes. In `golog++` durative actions are realised by using the keyword `start(action(args))` and `end(action(args))`. Between those commands different actions can be executed. However, in ROS2, the implementation of action execution is seperated with ROS2 actions, and services. The *ActionManager* and *ServiceManager* encapsulates the interface and execution with ROS2 action execution. A user only has to create a single function for every action, which is always about the conversion of a `golog++` value to a ROS2 message or vice versa.

These *Manager* template-classes generate clients for ROS2 action or service server that must implement the low-level actions. Also, all necessary functions to start and wait for the end of an action are generated.

For instance, every underlying ROS2 action has to implement the `build_goal()` function, which maps, in our example, the arguments of the `stack` action to a *goal* message for a ROS2 *action server*. In the future we plan to overcome this last repetitive boilerplate code with ROS2 introspection.

ActionManager: The mapping of the `action stack()` is shown in Figure 8. Inside `mapping` field, the first statement has to be the topic name of the corresponding action or service server as string.

When *execute_activity()* is called inside the *RosPlatformBackend* it passes an activity storing the mapping of an action, such as the topic name. This name is used to find the corresponding *ActionManager* object, which handles the execution. To create an *ActionManager* object, the ROS2 action type has to be passed as template argument, along with the topic name of the corresponding action server(Figure 8a line 1).

Then a mapping for the arguments has to be created. In the BAT, on the right side of the assignment, the arguments of the action itself are listed (yellow). On the left side, unique names must to be selected. Through these unique name, the values of the arguments can be accessed inside the *RosPlatformBackend*.

To interface with an existing ROS2 action server, an explicit function called *build_goal()* has to be implemented. This function maps those `golog++` arguments to variables of a ROS2 goal message. These arguments have to be cast into a ROS2 message data type. Therefore, depending on the datatype of the `golog++` value, different casts must be performed (e.g. *string*, *int*, *float*, *bool*).

This goal message is send to the ROS2 action server (Figure 8c), which utilizes the arguments to decide where to place which block. The ROS2 action server have to set a outcome either to *SUCCEEDED*, *FAILED* or *CANCELLED*. When the server finishes, a callback inside the *RosPlatformBackend* is triggered which passes this outcome to `golog++`.

The *ActionManager* executes every action asynchronously, and it is decided inside the `golog++` agent whether to start an action synchronously or asynchronously.

ServiceManager: In our *blocksworld* example, we employ active sensing with the `action update_block_pose(block x)` (Figure 5a) to update the location of the blocks in our agent from the ROS2 ecosystem. This sensing action is implemented as a ROS2 service, and it will only return a block or a table position for a given block.

Despite the implementation of a ROS2 service that provides a location, the *RosPlatformBackend* only requires an explicit template function, *build_request()*, to convert a ROS2 message value into a `golog++`

```
action stack(block x , location y ) {
precondition:
         x != y
       & loc(x) != y
       & (!exists(block z) loc(z) == x)
       & (!exists(block z) loc(z) == y)
mapping:
       " /stack " {
               block = x ,
               location = y
       }
effect:
       loc(x) = y;
}
```

(a) Agent stack action mapping.

```
create_ActionManager<spot_msgs::action::Stack>(" /stack ");

template<>
ActionManager<spot_msgs::action::Stack>::GoalT
ActionManager<spot_msgs::action::Stack>::
build_goal(const gpp::Activity &a) {
    auto goal = spot_msgs::action::Stack::Goal();
    goal.block =
    std::string(a.mapped_arg_value(" block "));
    goal.location =
    std::string(a.mapped_arg_value(" location "));
    return goal;
}
```

(b) Stack action mapped to ROS2 action server in *RosPlatformBackend*.

```
def begin_stacking( stack_gh ):
    block = stack_gh.request.block.lower()
    location = stack_gh.request.location.lower()

    # Calculate target angle
    target_angles, sec, nanosec =
    service_client.send_request(block, location,
                                is_block=True,
                                is_above=True)

    # Set target angle
    moveit_action_client.send_goal(target_angles, sec, nanosec)

action_server = ActionServer(
   stacker_node,
   Stack,
    ' /stack ',
    begin_stacking)
```

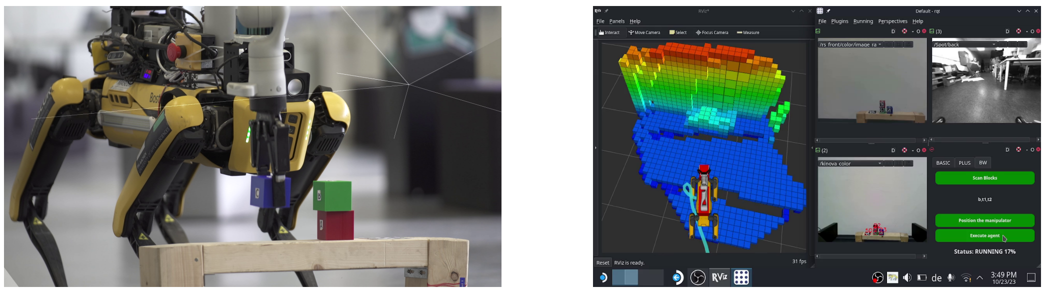
(c) ROS2 action server executes goal to stack blocks.

Figure 8: Interfacing the ROS2 Action Manager.

value for interfacing with this sensing action. This function is mandatory like the *build_goal* function of the *ActionManager*.

A ROS2 service server can provide a result in its response message. When setting the outcome for `golog++`, the result inside the *response* of the service can be passed along. Therefore the template function *to_golog_constant* has to be overridden and the result converted into a `golog++` value.

Within the agent, this result will be available with the type and value created from a ROS2 message converted with this function. In this context, the location



(a) Boston Dynamics' Spot solving blocksworld. (b) Visualisation of the robot's world state on a handheld controller.

Figure 9: The blocksworld task in real world.

provided from a response of a service server is stored in a *SymbolType*.

ExogManager: For our *blocksworld* example, no exogenous event is necessary. However, to use a `exog_action` an *ExogManager* has to be created inside the *RosPlatformBackend*. The *ExogManager* object is bound to a ROS2 topic and it will invoke the `exog_action` inside the agent every time a message is published to that topic. Therefore, a node is required that publishes a single message to the topic when the `exog_action` should be executed.

When initializing an *ExogManager* object, a template type as ROS2 message type has to be passed along with the topic name to react to. The template implementation generates all necessary instructions to create a ROS2 subscriber to this topic and a callback to react on the event. To pass values to the agent, an explicit function has to be written to convert the values of the ROS2 message to `golog++` values. Those values can be used inside the `effect` field of the `exog_action` inside the agent.

On the mascor github page is a detailed description of interfacing ROS2 with `golog++` and a debian package for installation.

Preparation

Figure 9b shows the user interface of the agent, running on a handheld controller, for executing the *blocksworld* agent. The interface includes the *RobotModel* on the left side, along with an *octomap* and the trajectory of Spot's path. Camera streams from Spot's grayscale and mounted *RealSense* cameras are visible, alongside buttons for execution control.

Initially, we sense the table pose and the locations of the cubes by clicking the *Scan Blocks* button (Figure 9b). This triggers a ROS2 node, calculating the position for all blocks with respect to the fluent `loc()`. First it detects the *aruco markers* positioned on the table and cubes. Then *transforms* are calculated, and converted to an element from our `domain`, and made available to a ROS2 topic for the sensing action to update the current location before planning. For easier placement of the cubes with the manipulator, the location *domain* includes the *symbol* elements *t1, t2, t3* for predefined positions of the blocks.

Following this preparation, the locations of the cubes are displayed on the handheld controller. The output here is *b, t1 ,t2*, which means *a* is on *b*, *b* on *t1*, and *c* on *t2*. This output allows an operator to verify the setup before executing the agent.

Execution

When initiating the agent, first the `action update_block_pose()` gets executed for all *blocks*, thereby updating the fluent `loc(block x)` for every block (see Figure 4). An underlying ROS2 service is then invoked to subscribe to the last message or the latest detected location, which is provided through the *RosPlatformBackend* as a domain symbol (see Figure 5a). The location was made available during the preparation step through a ROS2 topic.

The ROS2 Spot driver enables the robot to move to a pose or frame along a 2D plane using a ROS2 action. The `action navigateToFrame()` is interfaced with this action and passes a frame as a string type in its arguments. A target pose is defined based on the range of the manipulator, considering the distance between the table and Spot.

The actions `navigateToFrame("target")` and `setManipulatorJoints(..)`, (Figure 7), run asynchronously. `start()` triggers the asynchronous process, and `end()` specifies its expected completion. As `navigateToFrame` is already running in parallel, there is no need for `start()` statement for the second action.

Subsequently, the `solve(...)` statement generates an action sequence to stack the blocks from the initial to the goal situation. For instance, when `stack(a,t2)` is called, the custom action server, implemented with *MoveIt*, approaches the block, picks it up, moves to the target location, and places the block.

The last two `setManipulatorJoints(..)` commands retract the manipulator and return it to a safe home position.

6 CONCLUSIONS

In this paper, we showed our approach to interface the high-level action language `golog++` with our Spot robot. As a real world example, we showed how low-level actions implemented as ROS2 actions are mapped to `golog++` high-level actions in a unified way in order to execute actions such as stacking blocks with the Kinova Gen3 manipulator mounted on the robot with a handheld controller. In future work we plan to control multiple robots with `golog++` and a handheld controller.

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