Collaborator Kickoff Document

Description

The end-product will collaboratively operate on a shared workspace with human workers. What is meant by “collaboration” is that the robotic arms are currently unable to properly detect humans as cooperative agents. Our application will provide this core functionality. In detail, collaboration is a means to decrease workload of human workers by operating in the same environment through task sharing. The end users of the product will be those who lack human resources on labor-intense jobs on production lines.

Master Feature List

- MF-1: The robotic arm will be able to simply plan its motions for any valid 3D pose in the workspace.
- MF-2: The arm will be able to avoid colliding with uniform and simple obstacles in the workspace.
- MF-3: The arm will be able to avoid colliding with any form and size of obstacle in the workspace.
- MF-4: The arm will be able to recognize human-alike models to distinguish an ordinary object with a cooperative agent.
- MF-5: The arm will be able to recognize models that describe human and non-human in more detail such as cylinders for both arms and legs instead of cylinder of a human size.
- MF-6: The arm will be able to evade from human models without disrupting its own functionality in an unlimited 3D space, i.e. still realizes its job, but might be in a longer time span. This is a trade-off for its reliability.
- MF-7: The arm will be able to avoid from human models without disrupting its own functionality in a restricted 3D space, that is shared region.
- MF-8: The arm will be able to understand the hand gestures of human workers that indicate the human workers are done.
- MF-9: Prioritization of human worker based on collision probability measured by distance.
- MF-10: Avodiance of the robotic arm in the shared workspace when there is risk of collision with human worker.
- MF-11: The arm will be able to recognize whether the case is full or not. When full, it will automatically start its own operation.
- MF-12: The arm will be able to stack the cases referred as in the sample scenario.
- MF-13: The arm will have a safety layer that filters the physically damagable commands.
- MF-14: The arm will be able to operate in an infinite loop as embedded systems dedicated to accomplish its tasks.

Bonus Features:

- The robot will be able to operate with multiple workers.

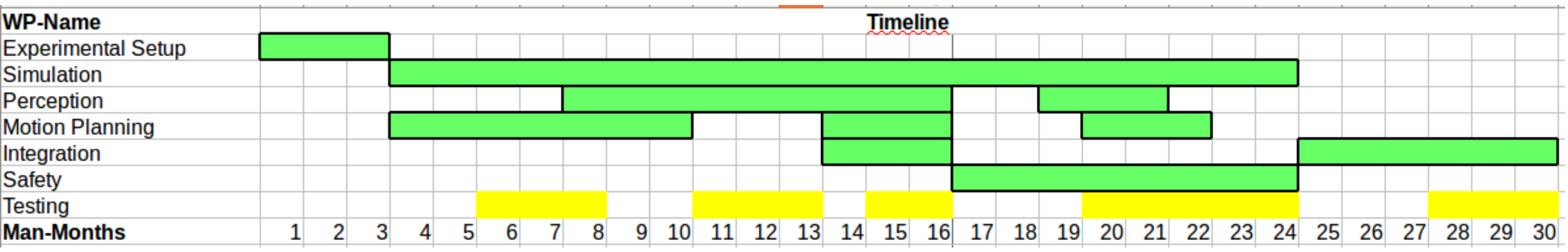
- The robot will be able to detect human worker(s) out of shared region.
- The robot will be able recognize voice commands of worker(s).

Work Packages

WP #	Term	WP title	Estimated number of man-months
1	491	Experimental Setup	3
2	491	Motion Planning	6
3	491	Perception	6
4	491	Simulation	-
5	492	Integration	3
6	492	Safety	6
7	492	Testing**	6

** Testing will be an interleaved work package that will be done throughout all work packages.

TimeLine



Detailed Descriptions of High-Level Workpackages

WP-1 Experimental Setup

In order to realize MF-1, we first need to design experimental setup both in simulation and physical world. This will include the designation of a simple table, a full case on it which is based on the scenario proposed. This work package does not include any Perception or Motion Planning, but our goal in here is to devise an environment in which the robot arm can complete its tasks such as we proposed in our sample scenario.

WP-2 Motion Planning

The development of MF-1, MF-2 and MF-3 will be fully finished only by this work package. MF-6,MF-7, MF-9, MF-10, MF-12 will be finished along with the Perception work package. In the above figure, it can be seem that some work packages might have aligned development processes. In this work package the simulations will be first handled, then we will move to the real-world testing. In detail, the robotic arm will first be aware of the pose of the case a priori in the simulation environment. We will plan the environment in that manner, because at that point we will not be doing any Perception yet. Hence, the problem reduces to the planning of horizontally consistent motion planning for the carrying operation. What we meant by horizontally consistent is that the robot should not make movements that might result in the fall of ingredients from the case. To provide this functionality, we will restrict our task space further.

In the second part of this work package, since the interleaved Perception work package will be expected to make progress, the Perception-Execution-Control Loop of the Motion Planning work package will be implemented.

WP-3 Perception

The development of MF-4, MF-5, MF-7, MF-8,MF-11 will be fully finished only by this work package. As already denoted in Motion Planning work package, relevant master features will be accomplished in cooperation. Specificially, the perception of different models will be handled in a building block manner such as the case, the ingredients of case, the robot, the table and after all the human. When all this done, gesture recognition will be implemented. In the early phase of the work package, we will represent the shared workspace with a markup in the simulation, such as distinct RGBD (D stands for Depth) values read by Kinect sensor. Then our program and the robotic arm will easily understand the region constiutes the shared volume. We can also use a characteristic vision-band to distinguish the shared volume. Also as a bonus feature, the speech recognition can be implemented in a way that recognizes the HALT orders of the human worker(s).

WP-4 Safety

The development of MF-13 will be done in this work package. Also, the hardware-related safety policies will be handled in the lab during this work package. Another importance of this work package is its relevance to the human worker(s) recognition. Since human worker is thoroughly different than other models and has a much more sensitivity to the damages, we need to devise safety measures in Motion Planning package along with Safety package. Also, the noisy inputs produced in Perception work-package must be purified in here to eliminate the possibility of ambiguity.

WP-5 Integration

This work package will cover the integration of the other work packages time to time. At first, the Perception and Motion Planning work packages will be integrated and later we will integrate Safety work package to the whole work. At the end of this work package, MF-14 will be satisfied.

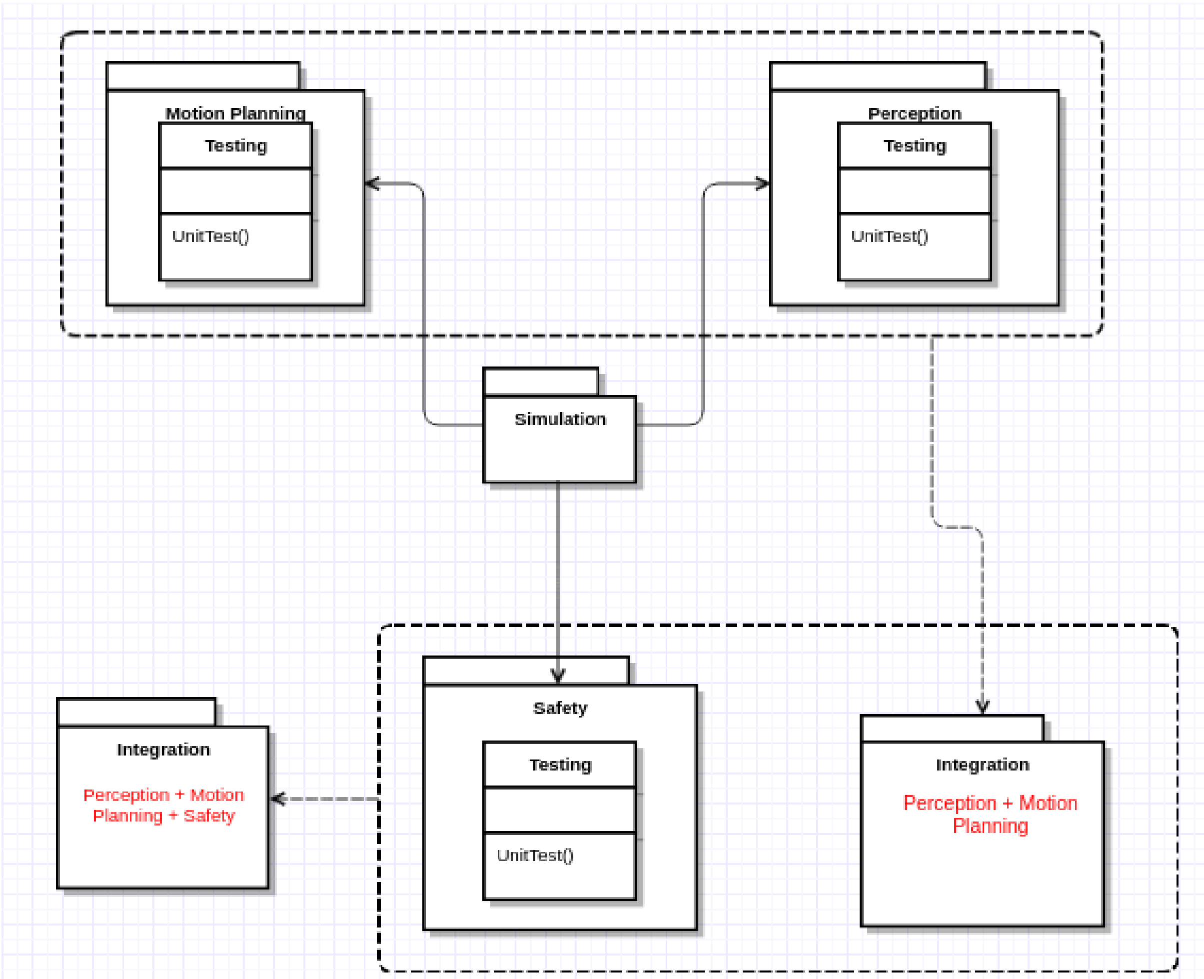
WP-6 Simulation

The simulation environments we will be using are Gazebo and Rviz. The Simulation work-package will be interleaved one, since we will be dealing with robotic arm and milestone scenarios in the virtual environment most of the time and then we will move to physical environment when all testing and simulation produce passing results. Also, this work package includes the early phases in all other work packages since it is needed to prepare virtual environments.

WP-7 Testing

In ROS, there is a Unit testing utility, which we will hugely exploit in our all development process and work packages. Also, mostly in Integration work package we will do component testings to make sure that the integrated parts work properly. An example to unit testing specific to our project is the testing of the data exchange between the Perception module and the Motion Planning module. These data are basically transmitted through ROS topics and all will have distinct ROS message types and the unit testing process will provide us reliability on these primal features.

Overall Systems Architecture



Risk Assesment

Risk #	Description	Possible Solution(s)
1	Noisy image output of the Perception Module	Reduction of the complexity of recognized human model.
2	The improper constraints of the Motion Planning Algorithms that are to be used	Hybrid algorithms which cancels each other drawbacks.
3	[-Pi,Pi] restriction of MoveIt Framework in order to avoid from possible singularity orientations.	Introduction of quaternions to the MoveIt API.