**MOnarCH Storyboards: Interactive Game Technical Script**

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# Introduction

This document details the “Interactive Game” storyboard. The goals for this storyboard are as follows:

* To demonstrate that a group of robots can help the staff at IPOL managing children in a closed environment (such as IPOL),
* To provide reasonable evidence (an unambiguous demonstration may be very difficult) that social relationships between children and robots can be established,
* To demonstrate that robots can be endowed with social interaction skills allowing them to mix with humans in social environments, using state-of-the-art techniques and off-the-shelf technologies.

One to two PO robots and three SO robots are considered.

The role of the PO robots is not explicit in this document. It is assumed that they behave without human-robot interaction concerns as their only objective is to obtain useful data for perception. However, they must behave according to the established social norms.

People participating in the MOnarCH trials are assumed to wear a wristband (or similar) with a RFID tag and eventually with some other sensing device.

The document is organized by definitions (section 1), required resources, both physical and functional (sections 2 to 5), and the script sequences (section 6).

The script is organized as sequences of scenes. Four possible initial scenarios are identified. For each of these scenarios, a full set of sequences of scenes is detailed. Continuity of the scenes must be ensured at all times to avoid having the system in deadlock/livelock situations.

# Interactive Game Rules

This section details the rules for the interactive game. The proposed game is a highly downsized version of the game-of-go. The focus is to have children interacting with robots and not showing strategic/tactical skills.

The game is played by 3 SO robots and 3 children.

The goal of the game is to have all the 3 players in the team reaching the starting line of the adversary. Each player can move forward or sideways, 1 step at a time, but it can not go backwards.

Figure 1 shows the gameboard representation as a 4 x 4 rectangular grid. At start, the 3 players on each team are distributed evenly at opposite sides of the board.

Each team chooses which player to move. Only 1 player can move at each time and it can only move 1 step to an intersection that is not blocked by another player.

|  |  |
| --- | --- |
| Figure : Gameboard | Figure 2: Starting board (black team vs blue team) |

# Definitions

**Role**: A set of behaviors all related to some specific task.

**Behavior**: An action on the environment (people included). It can lead to a robot moving, interacting through speech, etc. Compositions of behaviors to generate more complex behaviors are included here.

In general a behavior will be a composition of primitive behaviors.

**Primitive behavior**: An atomic behavior. Primitive behaviors are not intended to be decomposed into simpler behaviors. Examples are basic navigation, grasping, gestures, and voice dialogue.

**Perception component**: A provider of some perception feature. This includes algorithms running over either realtime data or data stored in some database that can be accessed concurrently by any component in the MOnarCH system.

**Interface**: A physical device (and associated drivers if appropriate) used to interact with the environment. A most natural interface is the robot itself as it interacts with the environment through motion. Other interfaces include speakers, LED arrays, etc.

**Event**: A condition of the system that is relevant for decision making. Some events are specific of the infrastructure and independent of the goals of the project. Examples are (i) the detection of emergency conditions, and (ii) communications with remote sensor are down. Other events are related to the project goals. Examples are (i) child is running, and (ii) a group of children is moving to the playroom.

Events related to infrastructure must be detected at all times. Events related to project goals may not need to be under observation at all times. For instance, the detection of a child running may not be necessary when the environment is quiet.

# Required Behaviors

**B01 - Cooperative coverage of the environment**

Description: Move around the environment, in cooperation with the other robots, such that a complete coverage is assured. Eventually, the coverage algorithms for PO and SO robots may differ.

**B02 - Human-aware wandering**

Description: Wander around the environment accounting at all times for the social dynamics.

**B03 - Point-to-point human-aware navigation**

Description: Go from point A to point B without too much concern for rigid social rules. Only a “reasonable” set of rules needs to be accounted for, namely those related to safety.

**B04 - Staff member greeting**

Description: Greet a staff member if it detects a wristband with a RFID tag id corresponding to a staff member.

**B05 - Show warm expressiveness**

Description: Show a warm expression, either by adopting some adequate motion, displaying some happy facial expression, or using some other anthropomorphic feature.

**B06 - Get child RFID id**

Description: Approach a child to get his/her RFID id. The approaching motion may not be subject to the same rules usually used for humans, e.g., should not approach from behind.

**B07 - Get Staff member RFID id**

Description: Approach a staff member to get his/her RFID id. The approaching motion may be subject to specific rules, e.g., always approach from front.

**B08 - Safe voice interaction reply to child**

Description: The robot speaks to a child in reply to some speech interaction from the child. The sentences are tailored to minimize the complexity of an interactive speech dialogue.

**B09 - Safe voice interaction with child**

Description: The robot speaks to a child without any prior speech from the child. The sentences are tailored to minimize the complexity of an interactive speech dialogue.

**B10 - Greet a child**

Description: This is just a specialized form of the “safe voice interaction with child” behavior.

**B11 - Follow a child**

Description: The robot follows a child from a safe distance. Children tend to have more erratic movements than adults and hence a safety distance bigger than for adults may be used. This behavior is a specialized (more complex) form of the more general behavior “follow a human”.

**B12 - Follow a staff member**

Description: The robot follows a staff member from a safe distance. This behavior is also a specialized (more complex) form of the more general behavior “follow a human”.

**B13 - Outrun a child**

Description: The robot moves ahead of a child to a specific point or area in the environment. This behavior may imply some timing, and not only distance, constraints.

**B14 – Cooperative outrun of a child**

Description: Similar to B13 but instead of having a robot moving too fast to outrun a child it uses a cooperative strategy. Assuming that multiple robots are spread around the environment, the child is outrun by the most adequate robot, for instance the one that can move safer.

**B15 - Cooperative child following**

Description: The cooperative version of the “Follow child” behavior. One robot may act as leader of the team of robots. This leader robot may follow the child. The other(s) robot(s) will cooperate/coordinate with the leader to reach specific goals. Some of the follower robots may use the “outrun a child” behavior.

**B16 - Child-Robot Interaction navigation**

Description: The robot moves in the neighborhood of a single child using proxemics rules.

**B17 - Children-Robot Interaction navigation**

Description: The robot moves in the neighborhood of a group of children using proxemics rules.

**B18 - Staff-Robot Interaction navigation**

Description: The robot moves in the neighborhood of a member of the staff trying to get her/his attention.

**B19 – Move to block access to forbidden area**

Description: The robot moves to block the access of a child to a forbidden area.

**B20 – Cooperative movement to block access to a forbidden area**

Description: Similar to B19 but using multiple robots moving in cooperation to block the access to a forbidden area.

**B20 – Cooperative movement to block access to a forbidden area**

Description: Similar to B19 but using multiple robots moving in cooperation to block the access to a forbidden area.

**B21 – Act as doorman at the classroom door**

Description: The robot places itself at the entrance of the classroom such that the RFID tags of the children can be easily detected. Eventually small movements may be required in order for the robot to unblock the entrance, letting the children going inside the room.

**B22 – Track a teacher**

Description: Move inside the classroom in order to maximize the probability of recognizing the commands (voice/gestures) issued by the teacher.

Due to the lack of space inside the classroom, specific motion strategies may be required.

**B23 – Augmented interaction using video**

Description: Use the video projector onboard to project multimedia contents on a wall (projection wall, room walls, or even in the classroom table).

**B24 – Gather a group of children**

Description: The SO robots cooperate to gather a group of children.

**B25 – Game navigation**

Description: Navigation strategy(ies) to be used when playing the interactive game.

# Required Primitive Behaviors

**BP01 - Point-to-point asocial navigation**

Description: Go from point A to point B avoiding obstacles.

**BP02 - Issue spoken message**

Description: Issue a speech portion. The message may be configured to be spoken in multiple tones. For example, there must be similar primitive behaviors using warm and cold voice tones.

**BP03 - Follow a human**

Description: Follows a child, staff member, or a participant in the trials from some predefined distance. This distance is fixed whenever possible and may be modified if the environment conditions require it. Eventually, changes in this safety distance must have some correspondence with changes in the robot velocity.

# Required Perception Components

### Basic Components

**PC01 - Robot localization**

Description: Returns the position and orientation of each robot in the system in world coordinates and the associated uncertainty. It uses sensor fusion whenever possible, i.e., when the data from each sensor is both reliable and not too old.

**PC02 - Robot localization from fixed cameras**

Description: Returns the localization of a robot using the images from the camera network.

**PC03 - Robot localization from onboard LRF**

Description: Returns the localization of a robot from laser range finder measures, eventually using a SLAM strategy.

**PC04 - Robot localization from bar code**

Description: Returns the localization of a robot from the detection of bar codes placed on the walls.

**PC05 - Robot localization from RFID tags**

Description: Returns the localization of a robot from the detection of RFID tags placed on the walls.

**PC06 - Shell touching**

Description: Returns information on the touching of the outer shell of a robot by a child.

**PC07 - Speech detection and recognition**

Description: Recognition of, at least, a set of sentences useful for MOnarCH. Eventually an off-the-shelf package will be used for this purpose. Whatever the package, in case it can not perform the detection it must return state information that can be used by the system for decision making purposes, e.g., the sentence is not loud enough for recognition purposes, sentence only partially recognized, etc.

**PC08 – Unmapped environment features detection**

Description: Detects changes between the environment known to the system (eventually stored in a knowledge base) and the current environment.

### Application-Related Components

**P01 - Detection of children groups**

Description: Estimate the position (in world coordinates) of a group of children. Yet to be decided the best metric. Eventually a mass-center like metric may be enough.

**P02 - Detection of single children (not in groups)**

Description: Estimate the position (in world coordinates) of a single child in the environment. Yet to be decided the best metric. It may depend on the specific sensors used.

**P03 - Recognition of children group activities**

Description: Examples of interest for the storyboard are playing, wandering, running, and static. The corresponding perception component(s) must estimate some dynamics parameters, e.g., an estimate for the group motion velocity.

**P04 - Recognition of single children activities**

Description: Idem the previous component but for a single child.

**P05 - Toy tracking**

Description: Tracking of the position of a toy tagged with RFID.

**P06 - Get RFID id for human (child / staff member / participant)**

Description: Get the RFID tag info from the wristband from child or staff (or any other participant). Eventually it may be necessary to separate this component in 2 different (more specialized) components as follows

* P06a – Get child RFID id

Children are normally smaller than adults and this type of physical feature may constraint the detection of the tags.

* P06b – Get staff member RFID id

Adults may wear wristbands with the tags but also may have a tag directly placed on clothes.

**P07 - Track a child**

Description: Tracks the position of a single child using the sensor network.

**P08 – Detect abandoned toy**

Description: Use imaging and/or RFID detection to find abandoned toys. This task may be carried out by the PO robots.

**P09 - Child social behavior recognition**

Description: Recognition of social activities of children. Examples are “child playing”, “child running”, “child talking to adult”, “child talking to other child”, “child agitated”, “child sleeping”, etc

**P10 – Children social behavior recognition**

Description: Identical to P09 but for groups of children.

**P11 - Track children**

Description: Similar to P07 but for groups of children.

**P12 – Gesture recognition**

Description: Use image data, from fixed cameras and cameras onboard the robots, together with wearable motion sensors, e.g. accelerometers, (used by the participating children much like the RFID tags) to detect specific gestures.

The full library of gestures to be detected is yet to be defined.

# Required Interfaces

**Motion**. This is an intrinsic interface, referred here just for the sake of completeness.

**Earing**. Microphones integrated within a speech recognition system.

**Voice**. Loudspeakers integrated within a dialogue management system.

**Display**. The physical installation of the display still to be defined by robot designers, e.g., as a face of the robot, as part of a torso, etc.

**Touch**. The shell of the robots may include touch sensors.

**Video projector**. This is part of the augmented interaction capabilities.

**LED arrays**. These may be used for facial expressions (mouth, eyebrows, face cheeks, etc).

# Scenarios and Scene Sequences

Three scenarios are distinguished as starting scenes.

1. Scenario 1: Everything is quiet.

This scenario is identical to that in the Joyful Warden and School Teacher storyboards. It is a continuity point between all storyboards.

1. Scenario 2: Children are wandering or playing single

This is similar to scenes in the Joyful Warden and the School Teacher storyboards. This scenario also provides continuity with the other storyboards.

1. Scenario 3: One or more groups of kids are playing

This scenario is identical to scenario 3 in the School Teacher storyboard. This scenario can also be an entry point from the other two storyboards.

Each of these scenarios is composed by multiple scenes. Figure 1 shows the estimated interconnections between the scenes.



Figure 3: Interconnections between the estimated scenarios/scenes

Similarly to the School Teacher, this storyboard is triggered at specific times to be defined by IPOL staff. When someone from the staff gives the order for a game to start the system selects the adequate starting scenario from the aforementioned ones and proceeds from that point on.

## Scenario 1 – Scene 1

Robots are either (i) quiet in some pre-defined areas or (ii) patrolling the corridor and playground room. Eventually, patrolling can be used by some of the PO robots to acquire information on the environment, i.e., re-check the consistency of environment map.

Children are behaving quietly not requiring any special attention from the robots.

If someone from the staff is seen for a first time in the day by any SO robot then the robot issues some greeting message.

This scenario can be followed by any other scene from any scenario.

Behaviors required: B03 (Point-to-point human-aware navigation). B04 (Staff member greeting). B05 (Show warm expressiveness). B01 (Cooperative coverage of the environment).

Perception required: P01 (Detection of children groups). P03 (Single children detection). PC08 (Unmapped environment features detection). P06a (Get child RFID id). P06b (Get staff member RFID id).

## Scenario 1 - Scene 2

Once someone from staff issues the command to start an interactive game one or two SO robots patrol the playroom and corridor announcing that it is class time.

The robots place themselves in strategic points near the entrances of the playroom that allow the detection of the RFID tag of the children passing by and hence know if enough children are already in the room for the game to take place. The robots act similarly to the doorman in the School Teacher storyboard.

As the children are detected the robots may greet them, encouraging them to move quickly to the playroom in order to start the game.

One SO robot may act a group leader asking the children to gather around him and, eventually, giving instructions to the children about the game. The idea is to clear the ground of any obstacles before the game starts. The robots may ask if someone (child or adult) is kind enough to clear the area so that the game can start.

Another of the SO robots may use the video projector to display results of previous matches.

Behaviors required: B06 (Get child RFID id). B10 (Child greeting). B09 (Safe voice interaction with child). B11 (Follow a child). B23 (Augmented interaction using video). B16 (Child-robot interaction navigation. B17 (Children-robot interaction navigation).

Perception required: P07 (Track a child). P06a (Get child RFID id).

## Scenario 1 – Scene 3

This scene applies when all children are in the playroom, the preparation for the game is completed and the game is about to start.

One of the SO robots asks for 3 children to touch him if they want to play. A second SO robot asks the other children to stay outside the game area.

As the game unfolds, the SO robots may (i) greet the children for a good play, (ii) express sadness because they or the children made a poor movement, (iii) cheering when the game ends.

Behaviors required: B09 (Safe voice interaction with child). B23 (Augmented interaction using video projection). B25 (Game navigation).

Perception required: P07 (Track a child). P06 (Get child RFID id).

## Scenario 2 – Scene 1

Similar to Scenario 1 – Scene 1. Robots are either (i) quiet in some pre-defined areas or (ii) patrolling the corridor and playground room. Eventually, patrolling can be used by some of the PO robots to acquire information on the environment, i.e., re-check the consistency of environment map.

Once is class time the SO robots act cooperatively to distribute themselves as in scenario 1, with one or two SO robot acting as doormen in the playroom and the other SO robot(s) moving around trying to gather the children and asking them to come play.

Scenario 1, scene 2, follows this scene.

Behaviors required: B02 (Human-aware wandering). B15 (Cooperative child following). B08 (Safe voice interaction with child). B06 (Get child RFID id). B21 (Act as doorman).

Perception required: P02 (Detection of single children). P07 (Track a child).

## Scenario 3 – Scene 1

Similar to scenario 2. Children groups are treated as if they were a single child. Dialogues must be adapted.

Behaviors required: B02 (Human-aware wandering). B15 (Cooperative children following). B08 (Safe voice interaction with children). B06 (Get child RFID id). B21 (Act as doorman).

Perception required: P01 (Detection of children groups). P10 (Track children).