



Virtual Laboratory

TECHNOLOGY

Robot design

User manual



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Terms and definitions

Term	Definition
Virtual Laboratory	Application «Virtual Laboratory «Technology», Section «Robot Design»
Click	Action involving: • when using a mouse — move the mouse pointer to the object, press and release the left mouse button without moving the pointer; • when using a touchscreen — tap the object with your finger and release without moving your finger
Portal	A resource of «42» LLC that provides users with access to educational materials and virtual laboratories
Scene	A virtual three-dimensional space within which the user can interact with the Application's objects. The concept of a «scene» also includes the data of the current scenario (object positions, their parameters, etc.)

1 General information

Application «Virtual Laboratory «Technology», section «Robot Design» (hereinafter referred to as the Virtual Laboratory) is a virtual space with a set of components for creating robots, modeling testing grounds, and creating custom challenges. The user has the ability to create an obstacle course where the robot interacts with objects, navigates by sensor signals, and performs tasks set by the user.

Access to the Virtual Laboratory is granted only after authorization on the Portal and with a valid license. Without meeting these conditions, launching the Virtual Laboratory is impossible.

2 System requirements

Minimum system requirements for the «Virtual laboratory «Technology», section «Robot Design»:

- **Processor:** Intel core i5 Gen 12, Apple Silicon M1 and newer.
- **RAM:** 16 GB or more.
- **Graphics Card:**
 - Integrated: Intel Iris Xe and newer;
 - Discrete: GeForce 1050 and newer.
- **Screen Resolution:** 1920x1080 / 1920x1200 or more (4K and Retina displays require a more powerful graphics card for comfortable operation).
- **Supported Browsers:** Chrome, Yandex.Browser, Opera 44+, Firefox 51+, Edge 79+, Safari 15+.
- **Supported Operating Systems:**
 - Microsoft Windows 10 (x64 versions) or higher with WebGL 2.0 driver support;
 - MacOS X Snow Leopard 10.6 or higher with WebGL 2.0 driver support;
 - Linux or Debian with WebGL 2.0 driver support.
- **Mobile Devices:** Running on mobile devices is not supported at this time!

3 Scene

When the Virtual Laboratory is launched, an empty scene opens (Figure 1).

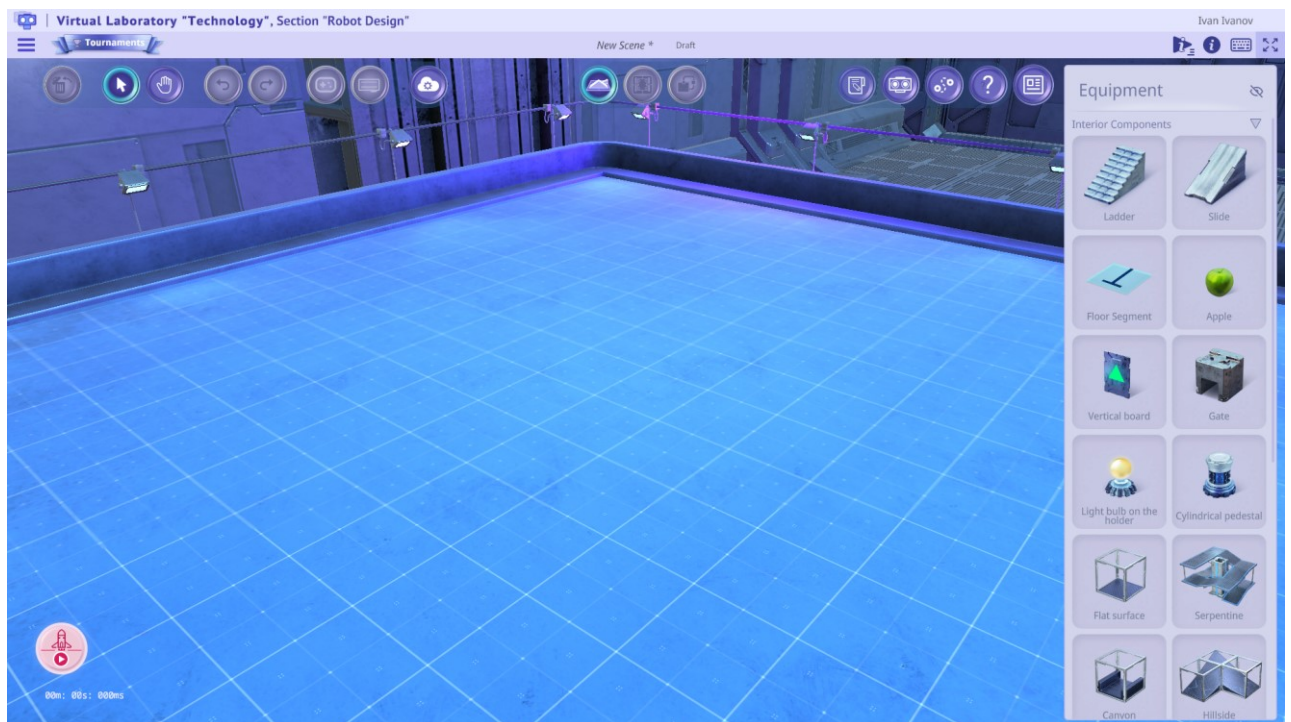


Figure 1 – Empty scene

4 Scene. Interface overview

This section provides a detailed description and functional purpose of the Virtual Laboratory interface elements. The scene contains the following elements (Figure 2):

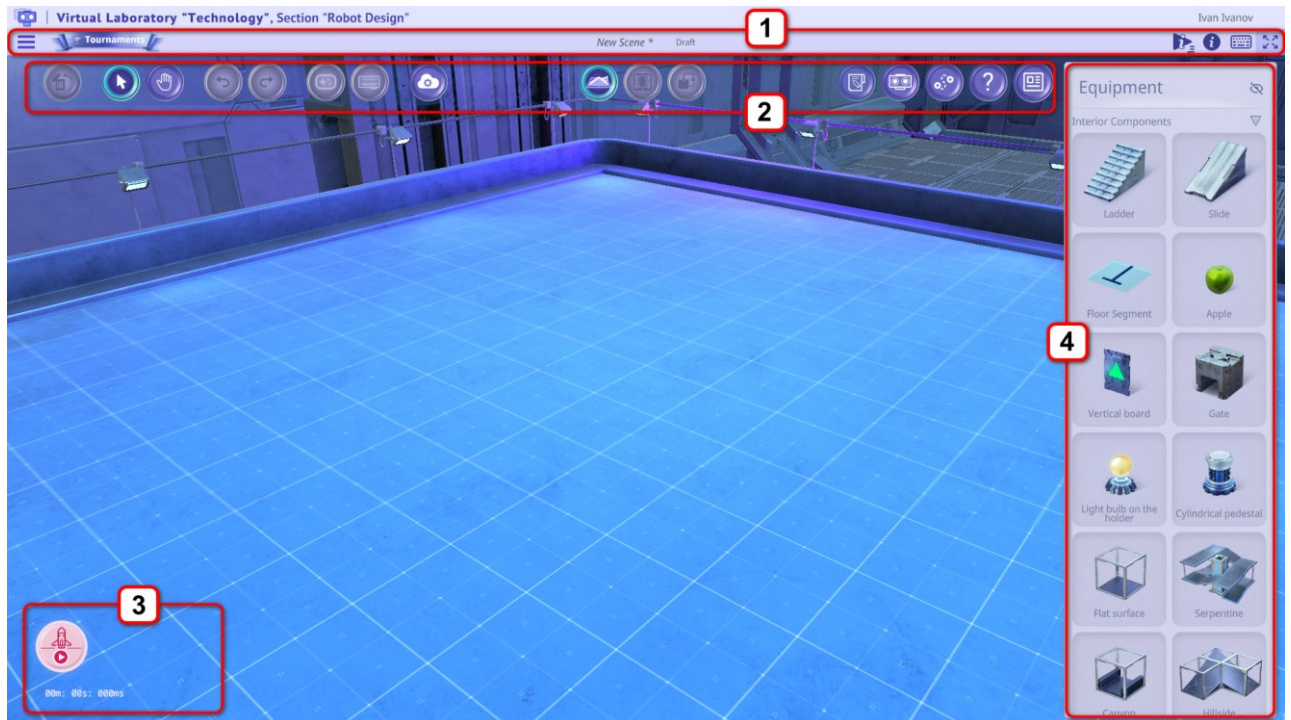


Figure 2 – Scene elements

- top information panel (1) (see 4.1 «Top information panel»);
- top button bar (2) (see 4.2 «Top button bar»);
- bottom button bar (3) (see 4.3 «Bottom button bar»);
- «Equipment» panel (4) (see 4.4 ««Equipment» panel»).

4.1 Top information panel

The top information panel contains informational and service application controls (Figure 3):

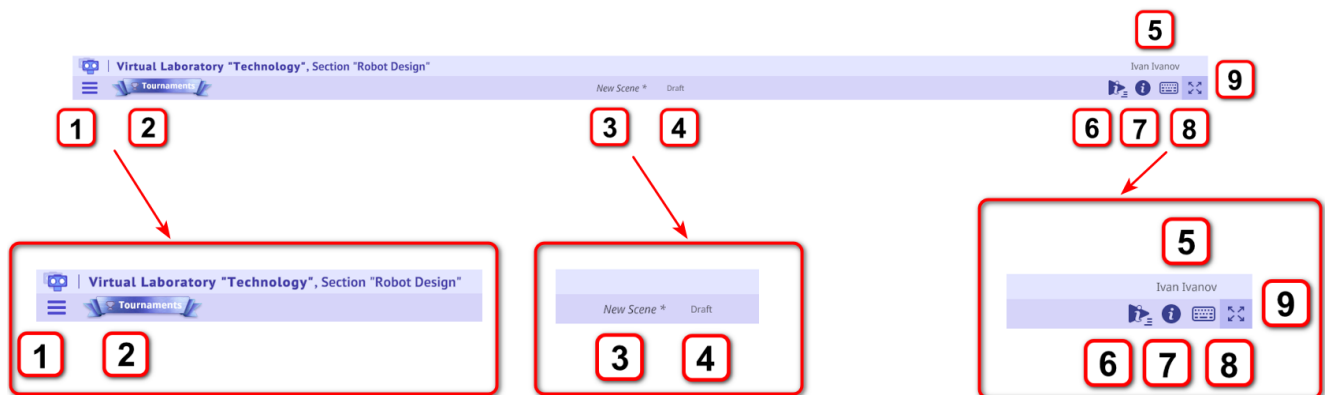


Figure 3 – Top information panel

- **Button for calling the internal application menu** (1 in figure 3). When clicked, the internal application menu opens (Figure 4), and the button itself turns into a close button. The menu can be closed by clicking anywhere on the screen outside its area.



Figure 4 – Internal application menu

Description of the internal application menu items:

- a) **The «New Scene» item** opens a new scene. If there are unsaved changes in the current open scene, a modal window appears on the screen asking for confirmation of the operation (Figure 5).

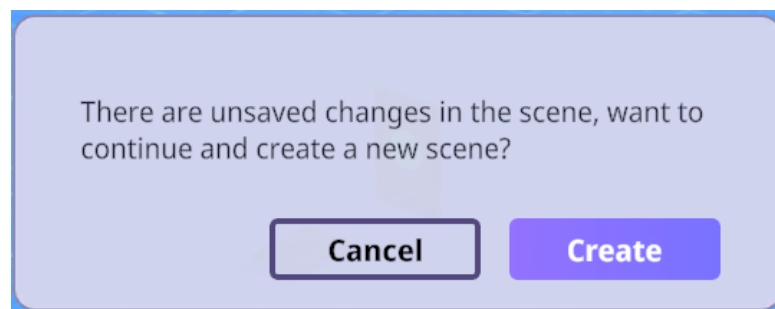
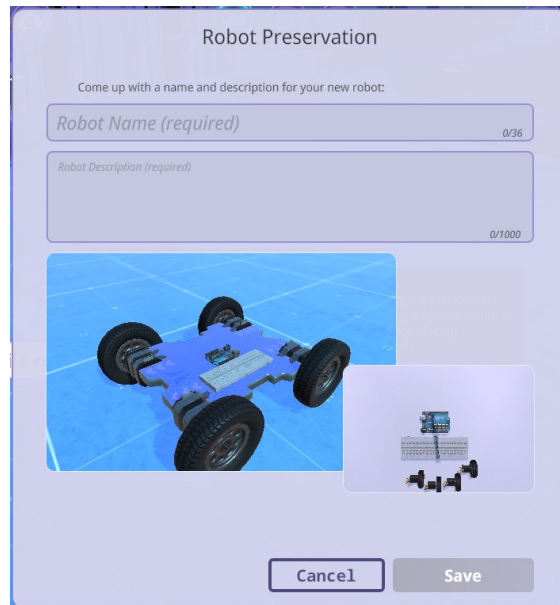


Figure 5 – Operation confirmation window

Clicking the «Create» button confirms the operation. Clicking the «Cancel» button cancels the operation and closes the confirmation request window.

- b) **The «Save a copy of the robot» item** opens a form for creating a new robot (Figure 6). This menu item is used to save the robot from the scene to the «Resource Library». The saved copy of the robot can later be used in other scenes, loaded onto testing grounds, or shared with other users. The menu item is available if the scene has at least a robot chassis.



Robot Preservation

Come up with a name and description for your new robot:

Robot Name (required) 0/36

Robot Description (required) 0/1000

3D model of a robot chassis and a wiring diagram.

Cancel Save

Figure 6 – Form for creating a new robot

Form for creating a new robot contains information fields describing the entity being created, as well as an image of its configuration and a wiring diagram of the components. When the «Save» button is clicked, a push notification appears confirming successful saving. When the «Cancel» button is clicked, the creation of the robot is canceled. The saved robot will be available in the «Robot Library» under the «My Robots» tab.

- c) The «Import robot» item opens the «Robot Library» (Figure 7), where the user can select a robot to add to the scene.

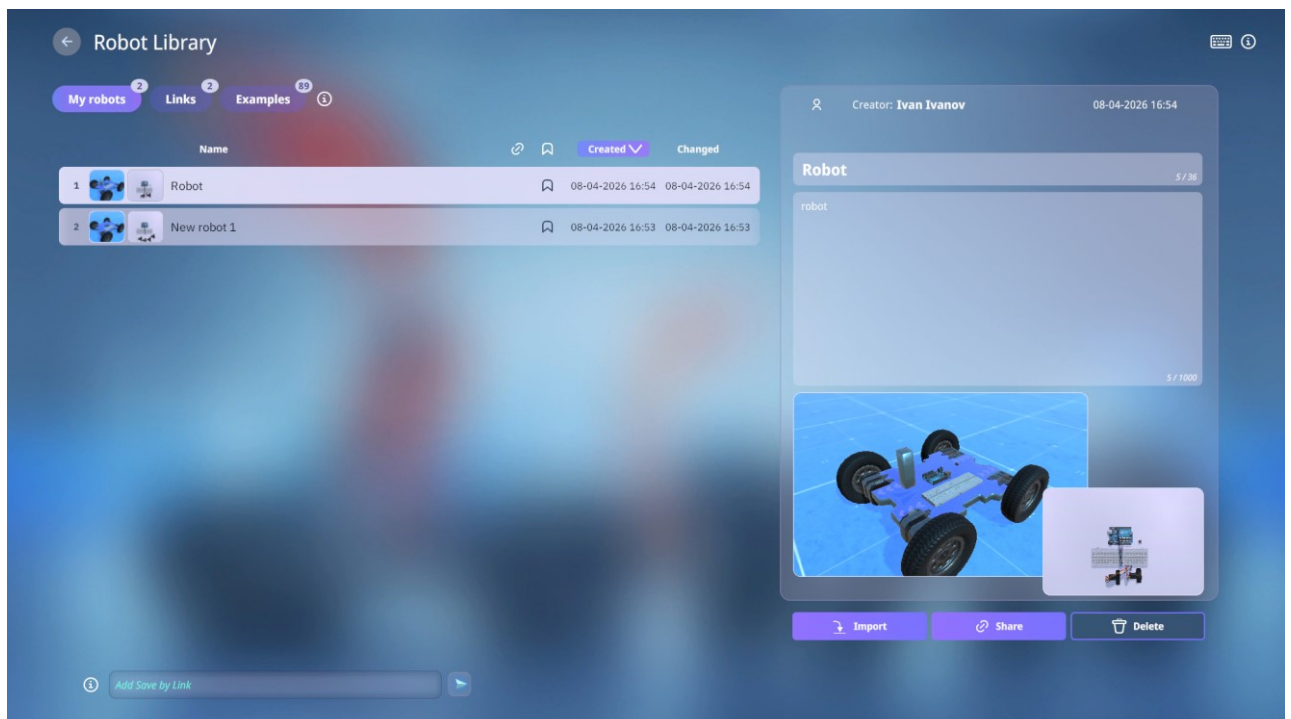


Figure 7 – «Robot Library»

Before opening the library, a confirmation request window appears (Figure 8). The «Cancel» button closes the window and cancels the operation, while the «Open» button proceeds to the library.

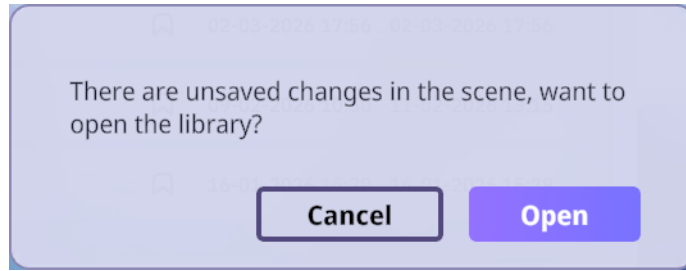


Figure 8 – Operation confirmation window

Upon successful import, the selected robot replaces the current robot in the scene.

- d) The **«Save a copy of the polygon»** item opens a form for saving the polygon (Figure 9). This menu item is used to save a copy of the polygon (the position and settings of all interior components in the scene) if the user wants to store it separately from the current scene. The menu item is available if at least one interior component is placed in the scene.

Figure 9 – New polygon save form

The new polygon creation form contains information fields describing the entity being created, as well as an image of its current configuration. When the «Save» button is clicked, a push notification appears confirming successful saving. When the «Cancel» button is clicked, the creation of the polygon is canceled. The saved polygon will be available in the «Polygon Library».

- e) The **«Import polygon»** item opens the «Polygon Library» (Figure 10), where the user can select a polygon (a set of interior components with their positions and settings) to add to the scene.

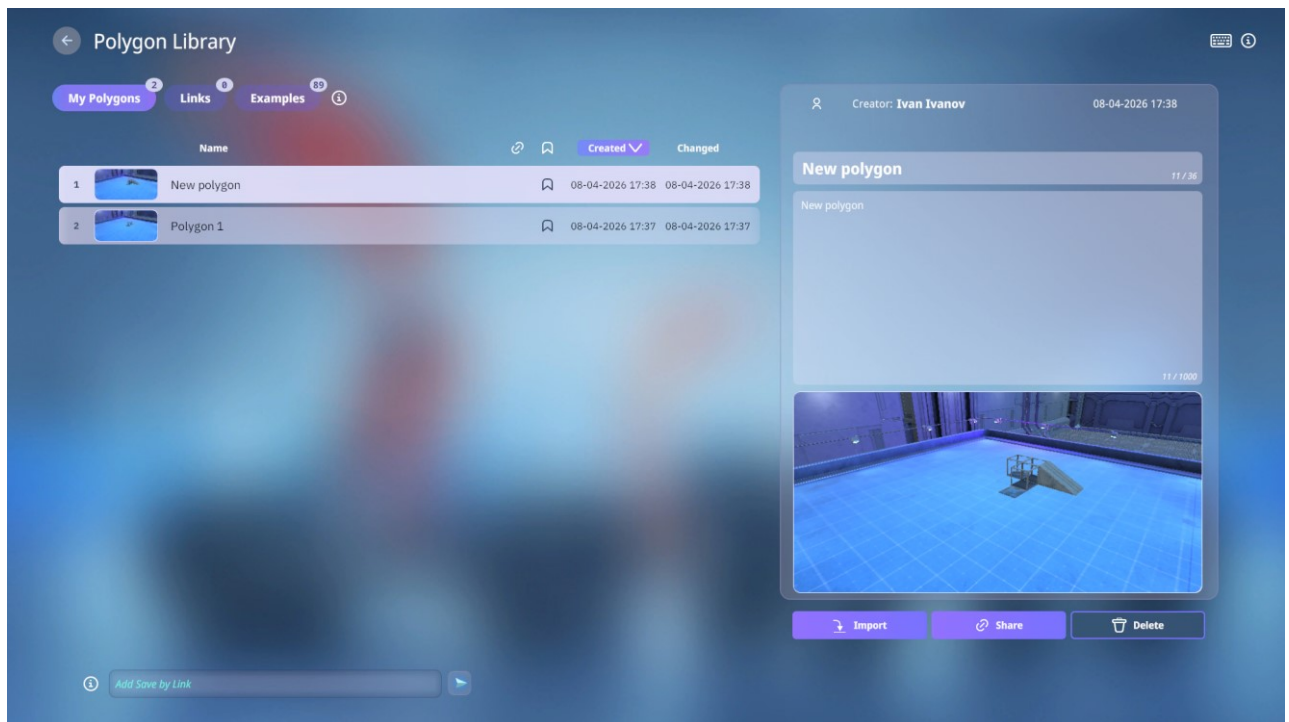


Figure 10 – «Polygon Library»

Before opening the library, a confirmation request window appears (Figure 11). The «Cancel» button closes the window and cancels the operation, while the «Open» button proceeds to the library.

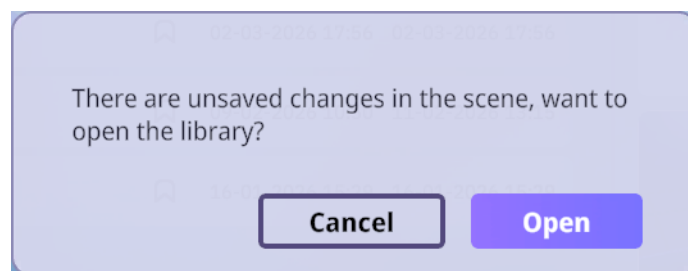


Figure 11 – Operation confirmation window

Upon successful import, the selected polygon replaces the interior components that were in the scene. If an interior component is placed where the robot is located, the robot moves to the unplaced components panel (see 4.8 «Must be placed» panel).

- f) **The «Save scene» item** is used to save the current state of the scene. If the created scene has not been saved and does not have an entry in the library, selecting this item opens the new scene creation form (Figure 12).

Figure 12 – Scene save form

The new scene creation form contains information fields describing the entity being created, as well as an image of its current polygon configuration and the robot placed in the scene with the attached wiring diagram. When the «Save» button is clicked, a push notification appears confirming successful saving. When the «Cancel» button is clicked, saving the scene is canceled. The saved scene will be available in the «Resource Library».

If the scene was previously saved in the library, the new version will replace the previous one when saving.

g) The **«Save a copy of the scene»** item opens the new scene creation form (Figure 12).

This menu item is used to save a copy of the scene that will not affect the state of the scene being created.

The new scene creation form contains information fields describing the entity being created, as well as an image of its current polygon configuration and the robot placed in the scene with the attached wiring diagram. When the «Save» button is clicked, a push notification appears confirming successful saving. When the «Cancel» button is clicked, creating the scene is canceled. The saved scene will be available in the «Resource Library».

h) The **«Scenes and challenges»** item opens the «Scene and Challenge library» (Figure 13).

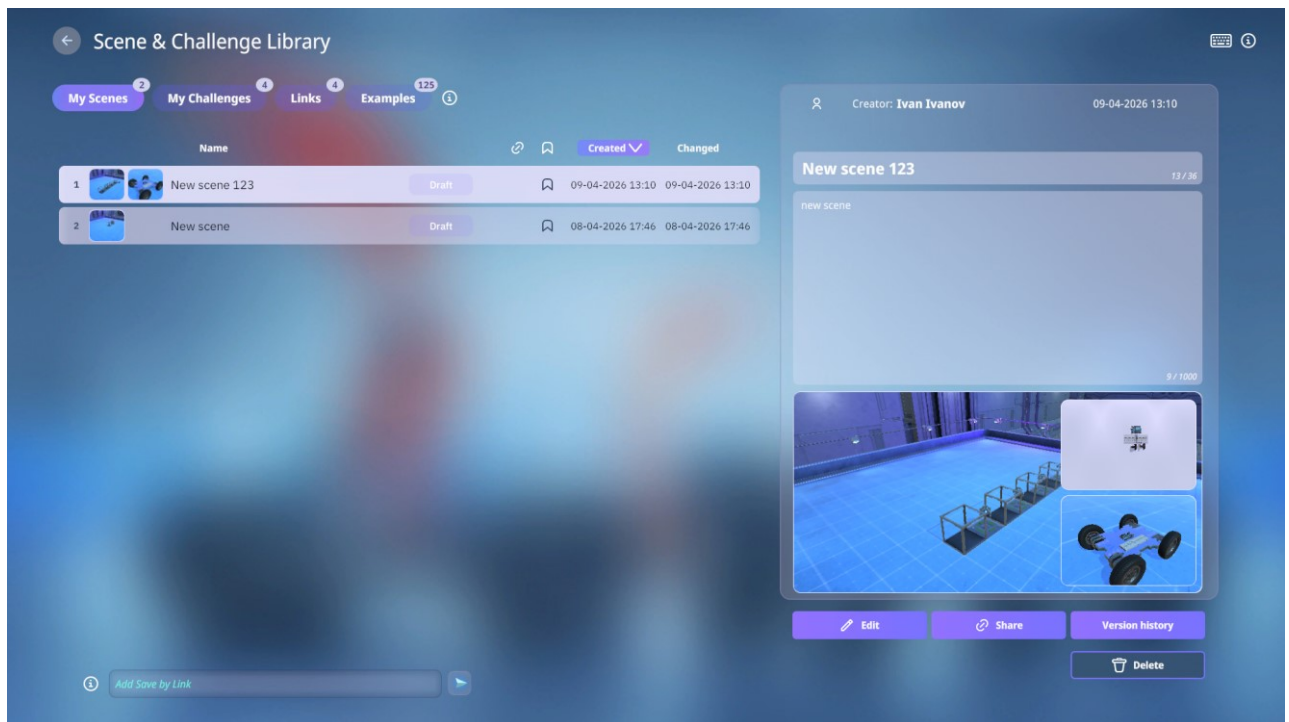


Figure 13 – Scene and Challenge library

Before opening the library, a confirmation request window appears (Figure 14). Clicking the «Cancel» button cancels opening the library. Clicking the «Open» button opens the «Resource Library».

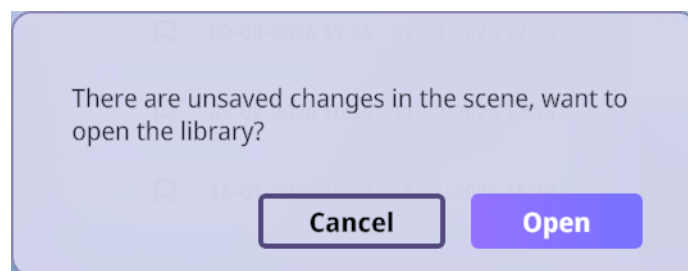


Figure 14 – Action confirmation window

- **Button for switching to the list of tournaments** (2 in figure 3). When clicked, the «My Tournaments» window opens with a list of active tournaments in which the user is participating (Figure 15). Detailed information about this functionality and the procedure for participating in tournaments is provided in the «Guide for Participants» document.

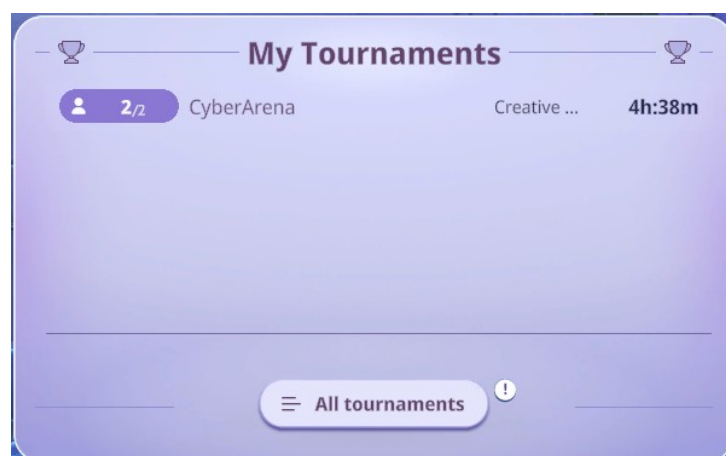


Figure 15 – «My Tournaments» window

- **Name of the current open scene** (3 in figure 3). The text contains the name of the current open scene. If the scene has not been added to the library, the default name «New Scene» is used. If the scene contains unsaved changes, an asterisk (*) is placed at the end of the text.
- **Status of the current open scene** (4 in figure 3). The status text indicates at what stage of creation the challenge is. Initially, the scene receives the status «Draft». After the user sets the conditions and independently completes the track, the status changes to «Ready to Publish». A published scene becomes a «Challenge».
- **First and last name of the current user** (5 in figure 3). The text displays the first and last name of the currently authorized user.
- **Button for calling instructions** (6 in figure 3). When clicked, an additional submenu opens with a list of instructions (Figure 16). When opening instructions:
 - text documents open in a new tab;
 - video instructions open in a player in the current window.

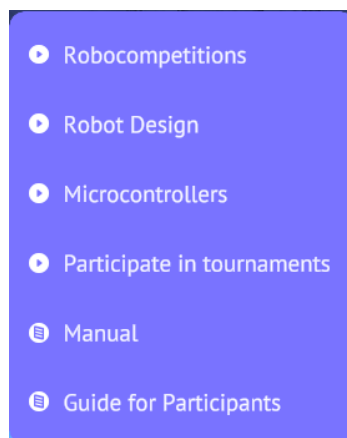


Figure 16 – Submenu with a list of instructions

- **Button for activating hint mode** (7 in figure 3). When clicked, hint mode is enabled (Figure 17). User interface elements and three-dimensional objects placed in the scene are equipped with information callouts. When a callout is clicked, a panel opens with hint text describing the corresponding element.

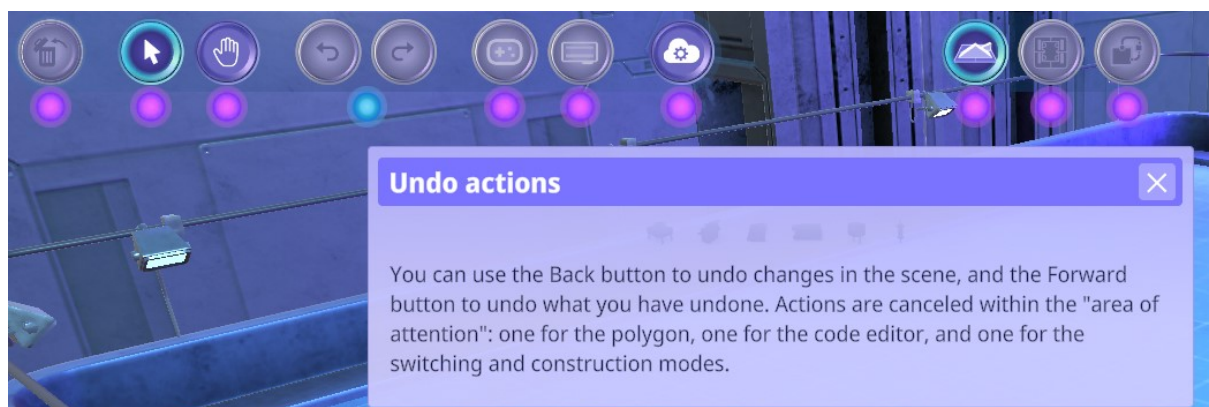


Figure 17 – Example of a panel with a hint and information callouts

- **Button for activating the on-screen keyboard** (8 in figure 3). When clicked, the Virtual Laboratory will invoke the on-screen keyboard each time the user interacts with character or numeric input fields. It is recommended to use this setting when working with touch screens.
- **Button for expanding the application to full screen** (9 in figure 3). When clicked, the Virtual Laboratory opens in full screen, hiding the browser frame and the operating system taskbar. To return to standard display mode, click this button again.

4.2 Top button bar

The top button bar contains scene controls necessary during the user's work (Figure 18).

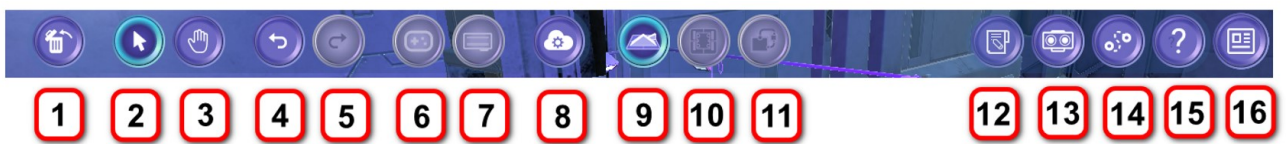


Figure 18 – Top button bar

- **«Clear scene» button** (1 in figure 18). When clicked, a panel opens with deletion options (Figure 19).

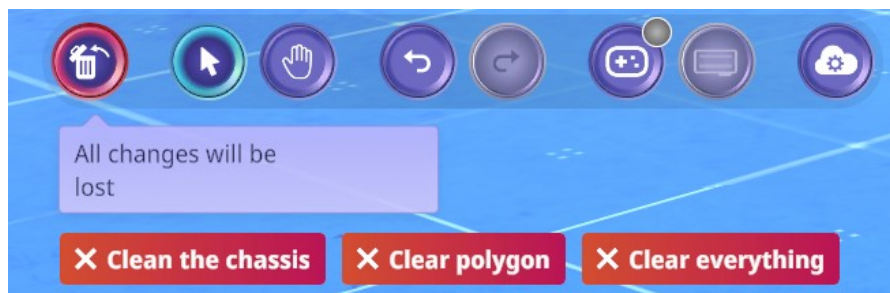


Figure 19 – Deletion options panel

Clicking the «Clear polygon» button removes all interior components from the scene. Clicking the «Clear everything» button removes all components from the scene without exception. If a chassis is placed in the scene with components mounted on it, a «Clear the chassis» button is additionally displayed on the panel. This button allows you to remove components only from the chassis surface without affecting other scene elements.

- **«Cursor» and «Hand» buttons** (2, 3 in figure 18). These buttons display the current user interaction mode with the scene. They are linked to each other: only one button can be active at a time. When the «Cursor» button is active, the user can select objects, move them, and edit their properties (rotate and adjust parameters). When the «Hand» button is active, interaction with the scene is limited to panning and zooming.
- **«Back» and «Forward» buttons** (4, 5 in figure 18). The «Back» and «Forward» buttons are used to undo or redo recent actions. The «Back» button can undo changes in the scene, while the «Forward» button can redo an undone action. Undo and redo occur within «areas of attention»: one for the polygon, one for the code editor, and a shared one for switching and construction modes. The «Forward» button becomes active only if there are undone actions that can be redone.

- **Button for calling the IR controller** (6 in figure 18). This button is used to open the IR controller panel. The button becomes active when an IR receiver is present on the robot chassis. A gray indicator is displayed next to the button, which turns green when simulation is started. To hide the IR controller view, click the button again.
- **Button for calling the LCD display view** (7 in figure 18). This button is used to open the LCD display. To hide the LCD display view, click the button again.
- **Button for calling the environment settings panel** (8 in figure 18). This button is used to open the environment settings panel. To hide the environment settings panel, click the button again or click outside this panel.
- **«Polygon mode» button** (9 in figure 18). The «Polygon mode» button is used to switch to polygon viewing and configuration mode. In this mode, the user can place interior components on the polygon and configure their parameters, as well as complete various tasks using the robot.
- **«Design mode» button** (10 in figure 18). The «Design mode» button is used to switch to robot design mode. In this mode, the user has the ability to spatially arrange components on the robot and configure their properties.
- **«Switching mode» button** (11 in figure 18). The «Switching mode» button is used to switch to the switching plane. In this mode, the user can create electrical connections between components.
- **«Challenge Conditions Panel. Conditions for passing» button** (12 in figure 18). This button is used to open the challenge conditions panel for further configuration. When clicked, the challenge conditions panel positions itself on the «Conditions of Passage» section.
- **«Challenge Conditions Panel. Terms of use of the robot» button** (13 in figure 18). This button is used to open the challenge conditions panel for further configuration. When clicked, the challenge conditions panel positions itself on the «Terms of Use of the Robot» section.
- **«Challenge Conditions Panel. The Fog of Challenge» button** (14 in figure 18). This button is used to open the challenge conditions panel for further configuration. When clicked, the challenge conditions panel positions itself on the «Fog of Challenge» section.
- **«Challenge Conditions Panel. Order and rewards» button** (15 in figure 18). This button is used to open the challenge conditions panel for further configuration. When clicked, the challenge conditions panel positions itself on the «Order and Rewards» section.
- **Button for calling the challenge conditions preview mode** (16 in figure 18). This button is used to open the summary panel for setting challenge conditions.

4.3 Bottom button bar

The bottom button bar contains the simulation button (Figure 20).

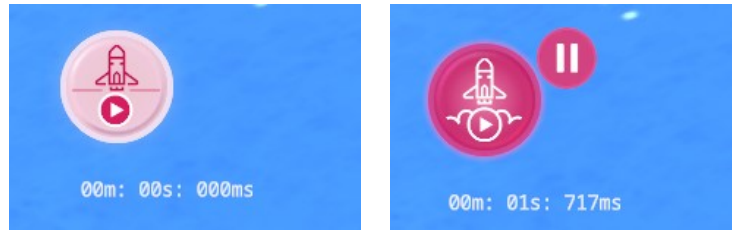


Figure 20 – Simulation button in inactive and active states

Clicking the simulation button starts a simulation session — the period of time during which the robot's operation in the scene is simulated. The timer below the button counts the time from the start of the simulation. During active simulation, an additional «Pause» button appears. Clicking it pauses the simulation, allowing the user to analyze the current state of the scene, sensor readings, or code execution. Clicking the «Pause» button again resumes the simulation.

4.4 «Equipment» panel

The Equipment panel is a tool for placing components in various scene modes (Figure 21). Depending on the scene mode (e.g., «Polygon mode» or «Design mode»), the user is provided with the corresponding set of components.

The panel includes the following elements:

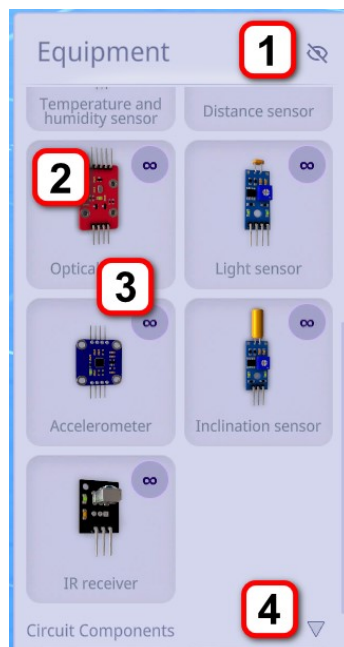


Figure 21 – «Equipment» panel

- «Hide panel» button (1);
- component cards (2);
- quantity availability indicator (3);
- component group collapse button (4).

When the «**Hide panel**» button (1) is clicked, the panel disappears. Instead, a «Show panel» button appears in the upper right corner of the screen.



Figure 22 – Appearance of the «Show panel» button

Clicking the «Show panel» button makes the Equipment panel reappear on the screen.

Component cards (2) represent the components that the user can use in the current scene mode. Methods of interacting with components are described in the relevant section (see [7.1 «General operations with components»](#)).

The **quantity availability indicator** (3) shows possible restrictions on the presence of certain components in the scene. The indicator is present only for those components that have a quantity restriction. If a component can be placed without restrictions, its card either has no indicator or contains an «infinity» symbol. If there is a restriction, the indicator shows the current and maximum allowed quantity and takes the form shown in figure 23.



Figure 23 – Appearance of the quantity availability indicator when a restriction is present

If the number of elements has reached the maximum, the component card is locked. An example of a locked component card is shown in figure 18.



Figure 24 – Appearance of a locked component card

4.5 Additional user interface panels

The user has access to a number of additional user interface panels.

4.5.1 IR controller panel

The IR controller view panel is used to control the robot (Figure 25). The panel can be moved around the workspace: hold the left mouse button on the panel and drag it to any location in the workspace.

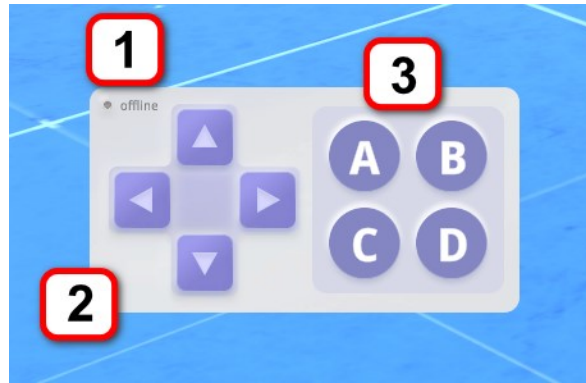


Figure 25 – Appearance of the IR controller

The panel contains: an indicator (1), direction buttons (2), action buttons (3).

The **indicator** (1) is gray if the simulation is not running. Next to the indicator there is the inscription «Offline». When simulation is started, the indicator turns green and the inscription changes to «Online».

The **direction buttons** (2) and **action buttons** (3) are used to send the corresponding code to the IR sensor.

The table below shows the correspondences between codes and buttons, as well as the hotkeys assigned to specific buttons of the IR controller.

Table 1— «Hotkeys»

Button name	Code	Hotkey
«Up»	FD1	W, ↑
«Down»	FD3	S, ↓
«Left»	FD4	A, ←
«Right»	FD2	D, →
«A»	FAA	R, numpad-4
«B»	FAB	T, numpad-5
«C»	FAC	F, numpad-1
«D»	FAD	G, numpad-2

4.5.2 LCD panel

The LCD panel allows the user to conveniently read information from the LCD displays placed on the robot (Figure 26).

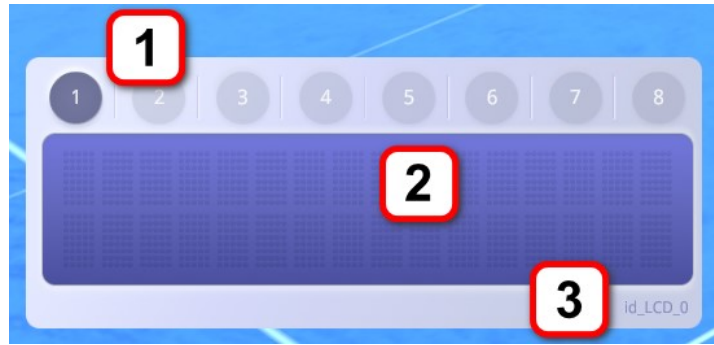


Figure 26 – LCD panel

The panel contains: a panel with buttons for selecting the display instance (1), the screen of the selected LCD display (2), the identifier of the selected LCD display (3).

4.5.3 Environment settings panel

The environment settings panel allows you to set the environmental parameters of the polygon that some sensors placed on the robot can interact with (Figure 27).



Figure 27 – Environment settings panel

The panel allows you to adjust the environment parameters: temperature (1), relative humidity (RH) (2), light level (3). Next to each parameter there is a button for calling the numpad (4) (Figure 28). When clicked, a numpad opens for entering a numeric value. After entering a number and clicking the «Apply» button, the numpad closes and the value is updated.



Figure 28 – Numpad

The user can also adjust the parameter value using the slider (5) located opposite the corresponding parameter.

4.6 Challenge conditions panel

The challenge conditions panel is designed to create the principles for completing the challenge and to establish the criteria for victory.

The challenge conditions panel contains four nested panels, each of which contains settings for a specific section of the challenge: conditions of passage, terms of use of the robot, fog of challenge, order and rewards.

4.6.1 Conditions for passing

The panel contains settings for the basic process of completing the challenge (Figure 29).

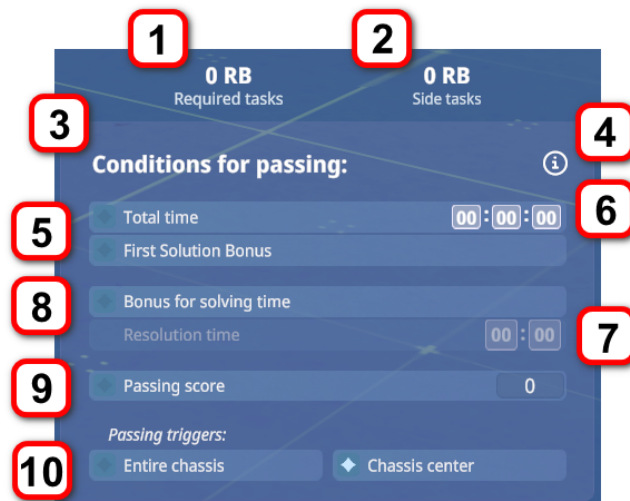


Figure 29 – «Conditions for passing» panel

Required tasks (1) — the minimum number of RB (robot points) that the participant must score to successfully complete the challenge. The parameter is set in the «Order and rewards» panel.

Side tasks (2) — the number of robot points that are optional. The user can earn them in parallel with the required tasks to improve their result.

«Conditions for passing» panel (3) — this panel opens when the user clicks the «Challenge conditions panel. Conditions for passing» button.

Information callout (4) — when clicked, a panel appears with a hint that describes the process of interacting with the «Conditions for passing» (Figure 30). To close the hint, click the «Close» button (the cross).

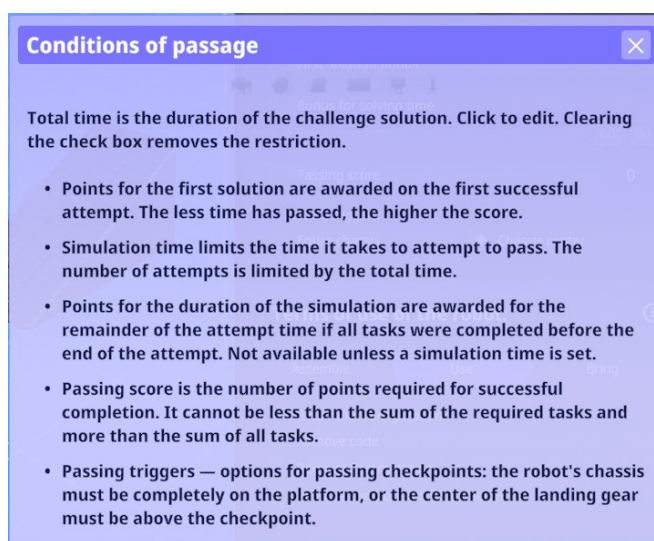


Figure 30 – Hint describing interaction with the «Conditions for passing»

Total time (5) — a parameter that sets the total duration of the challenge. If the parameter is left at zero, there will be no time limit. To edit the parameter, click on the time display area. A new time parameter settings panel will appear above the area (Figure 31), where you can set the desired time by clicking the up and down arrows. Each pair of up/down buttons controls the corresponding parameter.

To activate the parameter, click the checkbox located on the left side of the line. After clicking, the checkbox button becomes active. To close the time parameter settings panel, click anywhere on the «Conditions for passing» panel.

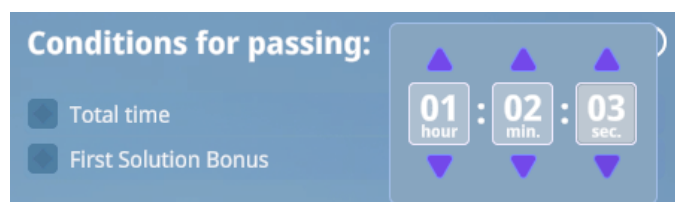


Figure 31 – Time parameter settings panel after changes

First Solution Bonus (6) — when this parameter is activated, the final score will depend on how quickly the user completed the challenge relative to the time available. To activate the parameter, click the checkbox located on the left side of the line. After clicking, the checkbox button becomes active.

Resolution time (7) — the challenge creator can limit the simulation session time available when completing the challenge. The functionality for setting the time parameter is similar to setting the **total time (5)**. To activate the parameter, click the checkbox located on the left side of the line. After clicking, the checkbox button becomes active.

Bonus for solving time (8) — when this parameter is activated, the number of points scored for a successful attempt to complete the challenge (simulation session) will be increased if the user completed the required tasks faster than the set session duration. To activate the parameter, click the checkbox located on the left side of the line. After clicking, the checkbox button becomes active.

Passing score (9) — the challenge creator can manually set the minimum passing score required to complete the challenge. The passing score value cannot be less than the sum of points for required tasks and greater than the total sum of points for all tasks. To set the passing score value, first activate the parameter, then highlight the input field and enter the desired numeric value. To activate the parameter, click the checkbox located on the left side of the line. After clicking, the checkbox button becomes active.

Passing triggers (10) — setting the principle for passing checkpoints (see [7.2.16 «Checkpoint»](#)). When the «Chassis center» option is selected, the checkpoint is considered passed if the geometric center of the robot chassis enters the zone. When the «Entire chassis» option is selected, the passage is considered passed if the entire robot chassis enters the checkpoint zone. By default, the «Chassis center» option is selected. To activate one of the options, click the checkbox located on the left side of the line. After clicking, the checkbox button becomes active. The second option will be automatically deactivated.

4.6.2 Terms of use of the robot

The «Terms of use of the robot» panel allows you to configure the principles of user interaction with the robot during the challenge (Figure 32). The panel contains a selection of usage modes and also enables the creation of restrictions and requirements for the components that make up the robot.

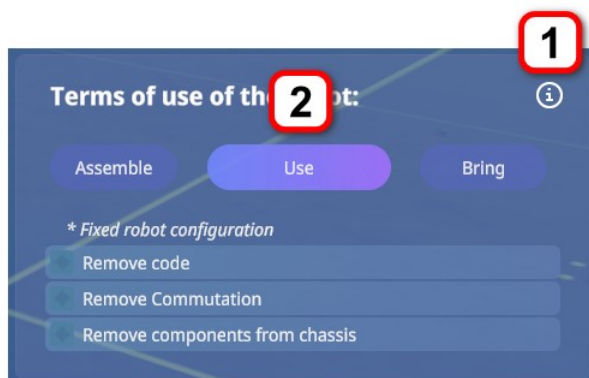


Figure 32 – «Terms of use of the robot» panel

Information callout (1) — when clicked, a panel appears with a hint that describes the process of interacting with the «Terms of use of the robot» (Figure 33). To close the hint, click the «Close» button (the cross).

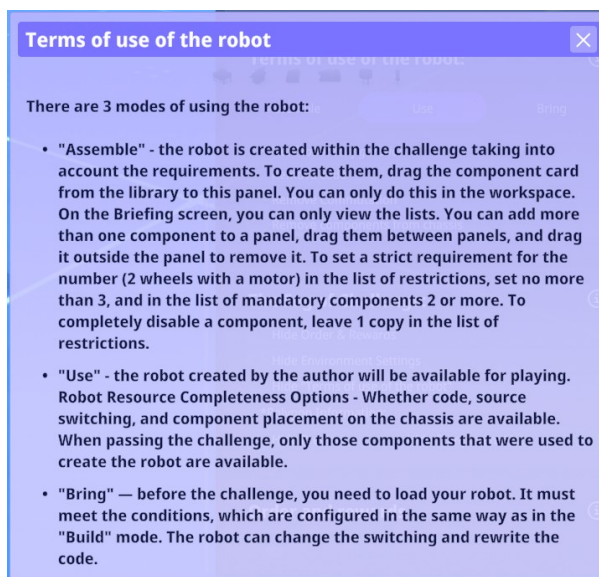


Figure 33 – Hint for the «Terms of use of the robot» panel

Selecting the robot usage mode (2) — a list of interaction options with the robot during the challenge. The user can use a ready-made robot, build their own version (assembly is included in the challenge process), or use their own robot already available in the «Resource Library».

«Assemble» mode. If the challenge creator selects the **«Assemble» mode**, they can set requirements and restrictions for the components that will be included in the robot assembly during the challenge. The appearance of the panel when this mode is selected is shown in figure 34.

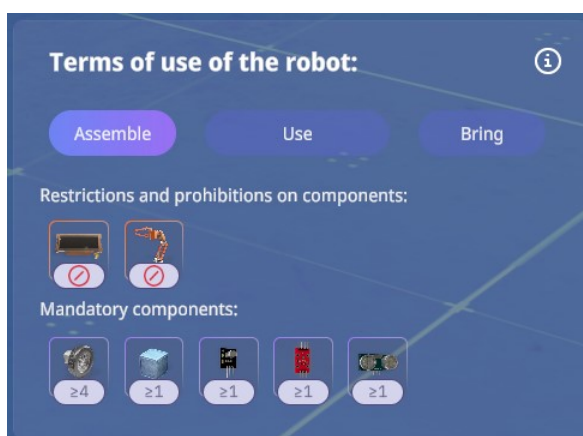


Figure 34 – Appearance of the panel when the «Assemble» mode is selected

When this mode is selected, two areas appear in the panel: «Restrictions and prohibitions on components» and «Mandatory components». The first area is used to create a prohibition or quantitative restriction on the use of components. The second is used to set a requirement for the mandatory use of components.

To set these restrictions, use the «Equipment» panel and drag component cards from there into one or another area. To increase the number of components of the same type in a particular area, repeat the operation.

If it is necessary to specify the exact number of components required for use on the robot during assembly, the restrictions and requirements must be set so that in the upper area the number on the component card is one more than the number on the card of the same element in the lower area (Figure 35).

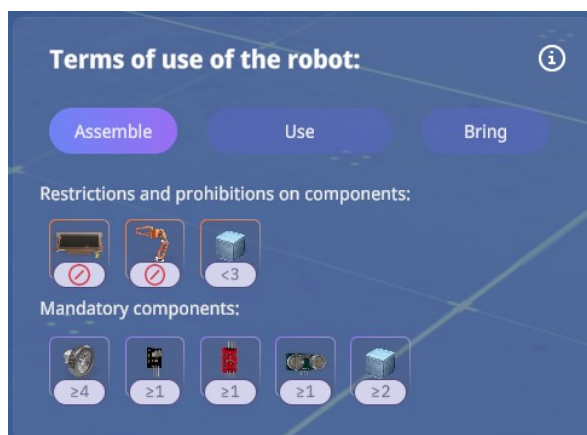


Figure 35 – Example of setting restrictions on the use of components

To remove a restriction or requirement from a component, drag the component card out of the area and release. The card will be deleted, and the restriction or requirement will be removed.

If a restriction is set on a component, the card of that component in the «Equipment» panel will receive a new quantity indicator. The appearance is shown in figure 36.

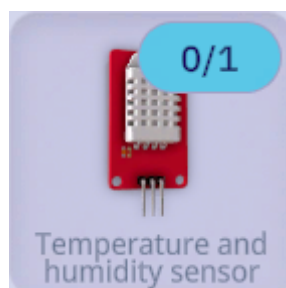


Figure 36 – Appearance of a component card when a quantity restriction indicator is present

If the current robot assembly does not meet the conditions set in the «Terms of use of the robot» panel, a system warning is displayed (Figure 37). It informs the user that the completed route will not be counted for preparation for publication until the discrepancies are resolved.

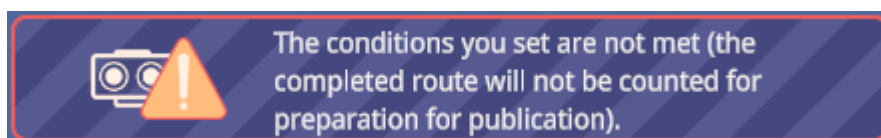


Figure 37 – Warning about non-compliance with conditions

If requirements are applied to a component that set a minimum mandatory quantity, an indicator appears on the component card in the «Equipment» panel showing whether the current number of components of that type meets the established minimum. If the requirement is met, the current quantity indicator turns green. The appearance of the indicator is shown in figure 38.

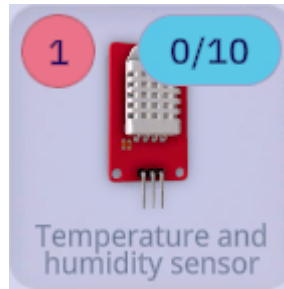


Figure 38 – Appearance of a component card when a current quantity indicator is present

«**Use**» **mode**. If the user selects the «**Use**» **mode**, the robot that was assembled to create the challenge will be available to all other users.

When the «Remove code» parameter is selected, the original robot code will be hidden from the challenge participant. When the «Remove commutation» parameter is selected, the challenge participant will have to create the wiring themselves during the challenge. When the «Remove components from chassis» parameter is selected, all components will be moved to the unplaced components panel (see 4.8 «**Must be placed**» panel»). The participant will need to place all components on the robot during the challenge.

«**Bring**» **mode**. If the user selects the «**Bring**» **mode**, the challenge participant will need to load a robot from their «Resource Library». The appearance of the panel when this mode is selected is shown in figure 39.

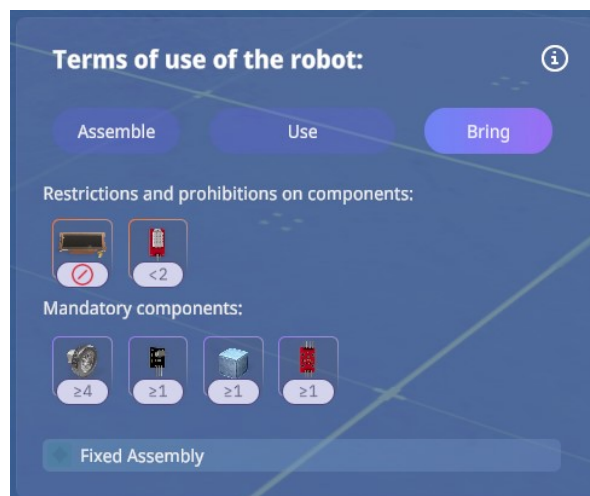


Figure 39 – Appearance of the panel in «Bring» mode

The panel displays areas for requirements and restrictions that work on a principle similar to the «Assemble» mode.

When the «Fixed assembly» parameter is activated, the challenge participant cannot edit the robot after the start of the challenge.

If the creator has set a set of requirements and restrictions, starting the simulation will check whether the current robot configuration matches the established conditions. Since the challenge creator must first complete the challenge themselves to prove its feasibility, all conditions must be strictly met. Otherwise, the «Terms of use of the robot» panel changes its appearance, notifying the user of a discrepancy between the conditions and the current configuration. The appearance of the panel is shown in figure 40.

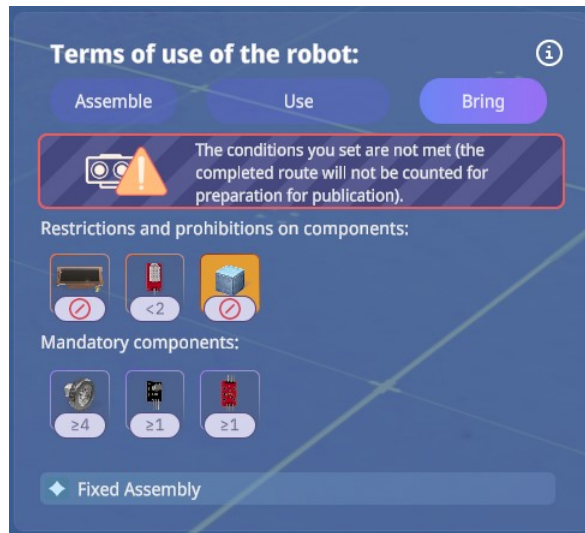


Figure 40 – Appearance of the panel when there are discrepancies in conditions and configuration

An additional pop-up warning appears in the scene workspace (Figure 41). It duplicates the information about the assembly not meeting the specified requirements and contains a recommendation to install all mandatory components before trying again.

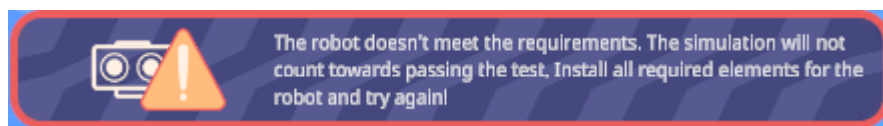


Figure 41 – Warning about a discrepancy in conditions and configuration

If discrepancies exist, a successful attempt to complete the challenge will not be counted for preparing the challenge for publication.

4.6.3 Fog of challenge

The «Fog of challenge» panel allows you to configure the completeness of the challenge description visibility for the participant before the start of the challenge (Figure 42).



Figure 42 – «Fog of challenge» panel

Information callout (1 in figure 42) — when clicked, a panel appears with a hint that describes the process of interacting with the «Fog of challenge» panel (Figure 43). To close the hint, click the «Close» button (the cross).

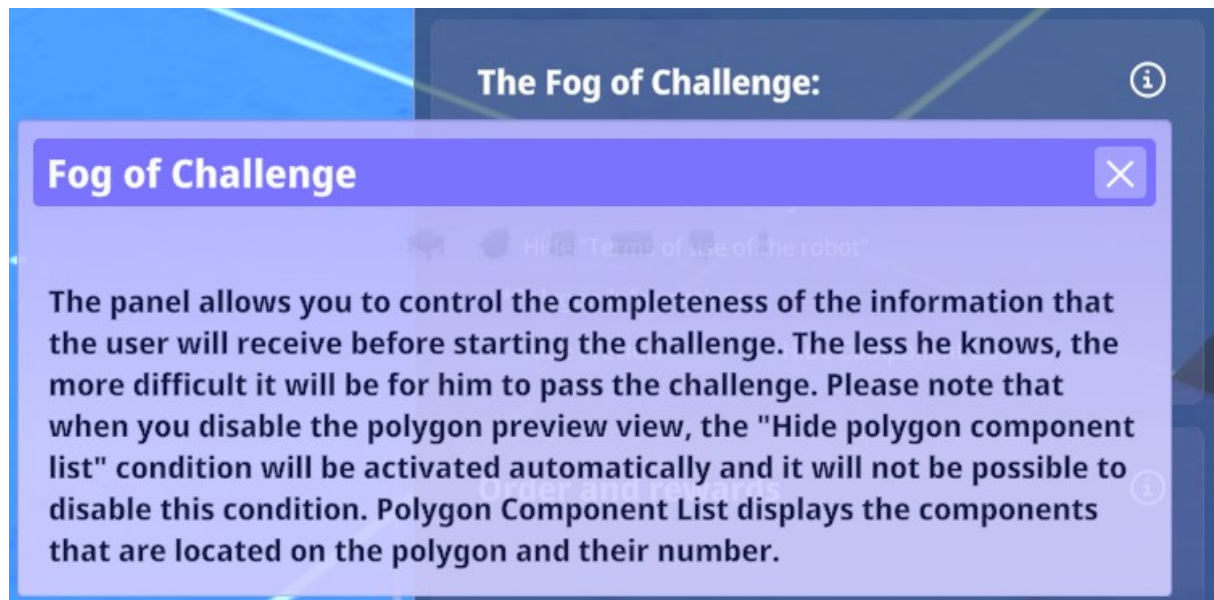


Figure 43 – Hint for the «Fog of challenge» panel

When the **«Hide Order and Rewards»** parameter (2 in figure 42) is activated, the challenge participant will not know in advance how many checkpoints or other tasks they need to complete.

When the **«Hide environment settings»** parameter (3 in figure 42) is activated, the challenge participant will not have access to the environment settings panel. Information about it will only be available via sensors.

When the **«Hide «Terms of use of the robot»** parameter (4 in figure 42) is activated, the challenge participant will not know in advance the details of the robot usage conditions. This parameter can only be activated if the robot usage mode is set to «Assemble» or «Use».

The options for the **«Polygon information»** parameter (5 in figure 42) are mutually exclusive. When the «Hide preview» option is selected, the participant will not see the polygon fragment image. When the «Hide component list» option is selected, the participant will not see the list of polygon components with the quantitative display of interior components placed in the challenge scene.

4.6.4 Order and rewards

The **«Order and rewards»** panel allows you to configure the sequence of completing the challenge, the «cost» of each task, and also set the requirement for the mandatory completion of a particular task (Figure 44).

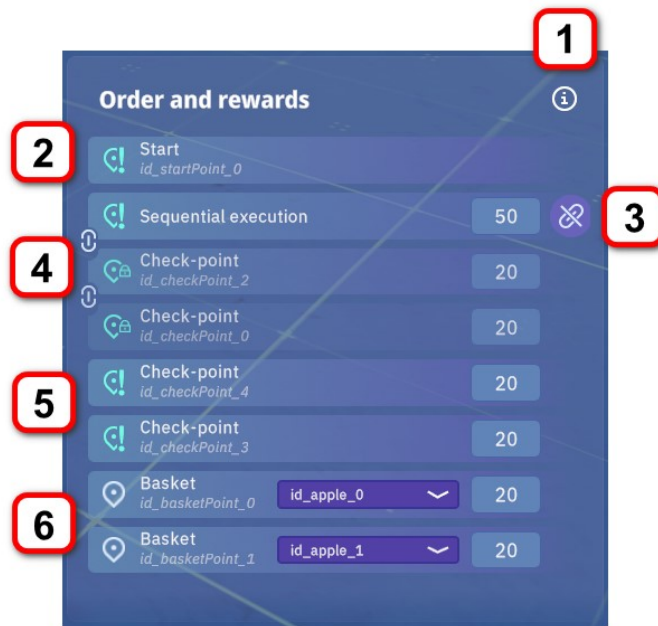


Figure 44 – «Order and rewards» panel

Information callout (1 in figure 44) — when clicked, a panel appears with a hint that describes the process of interacting with the «Order and rewards» panel (Figure 45). when clicked, a panel appears with a hint that describes the process of interacting with the «Order and rewards» panel.

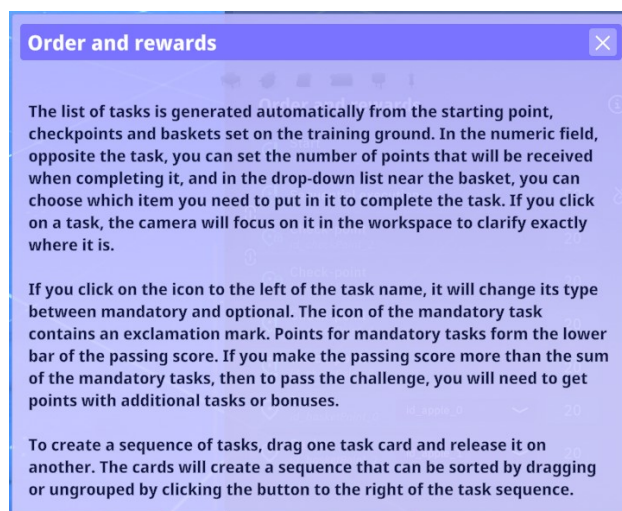


Figure 45 – Hint for the «Order and rewards» panel

The «**Start**» component (2 in figure 44) placed in the scene sets the starting point of the challenge. The component receives its entry in the panel, as do the other tasks. This means that the participant cannot independently choose the point where the robot will be placed at the start of the challenge.

The user can drag a checkpoint or other task entry onto another one. After dragging, the entries form a **sequence** (4 in figure 44), that has its own point «cost». This means that to earn additional points, all tasks in the sequence must be completed in that exact order. To **split the sequence**, click the button (3 in figure 44).

A task has a **required** attribute. An **optional** task (6 in figure 44) can be skipped — it does not affect the successful completion of the challenge. A **required** task (5 in figure 44), on the contrary, must be completed. To change the task status, click the icon on the left side of the line: it becomes active and the task becomes required.

For baskets, there is additionally the ability to select the object that needs to be placed in it. This allows you to clarify the task for the participant. The object is selected from a drop-down list and is displayed in the basket line.

4.7 Challenge information panel

The challenge information panel displays the challenge data on a single screen (Figure 46).

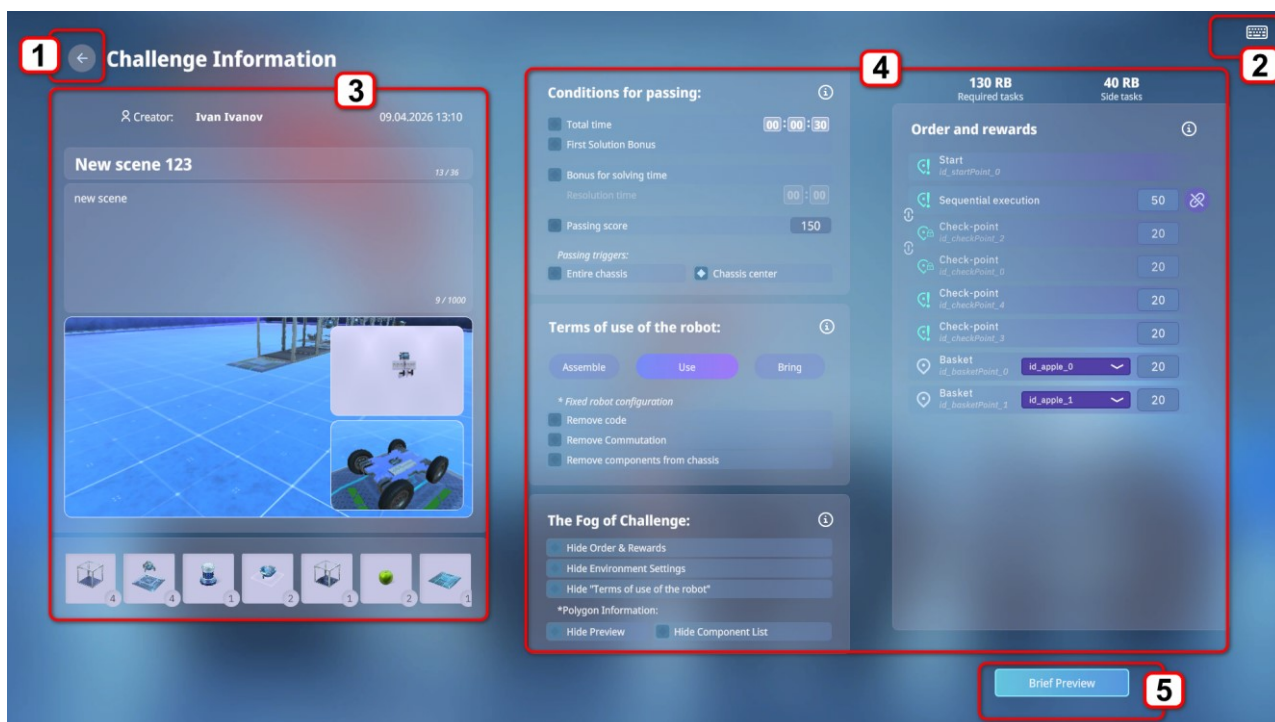


Figure 46 – «Challenge information» panel

Clicking the **«Back» button** (1) hides the panel, returning the user to the scene.

Clicking the **«Activate on-screen keyboard» button** (2) will invoke the on-screen keyboard each time the user interacts with character or numeric input fields. It is recommended to use this setting when working with touch screens.

Basic challenge information (3) contains the name and description of the challenge, images of the polygon, the robot and its wiring diagram, as well as a list of interior components used to build the track.

Challenge conditions information (4) includes the following parameters: conditions for passing, terms of use of the robot, fog of challenge, order and rewards (see 4.6 «Challenge conditions panel»).

Clicking the **«Brief preview» button** (5) opens the «Challenge briefing» page, which contains information about the challenge (passing score, conditions, order and rewards) (see 4.10 ««Challenge briefing» panel»).

4.8 «Must be placed» panel

The «Must be placed» panel appears when any robot components are not placed on the chassis (Figure 47).

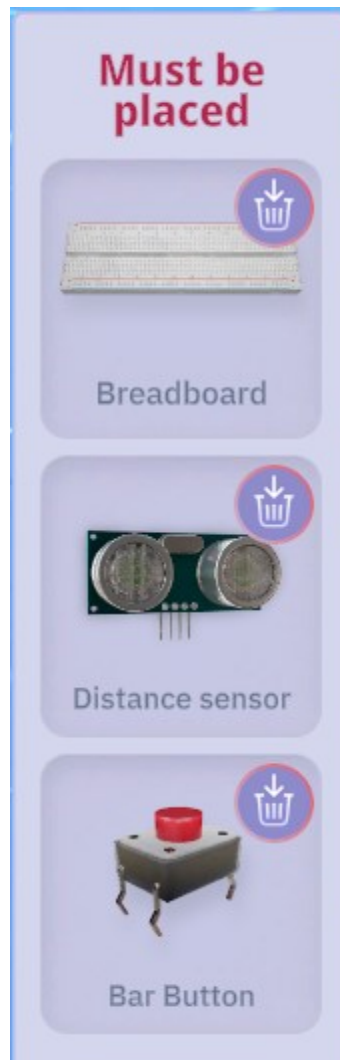


Figure 47 – «Must be placed» panel

If unplaced components appear in the scene, an indicator showing the number of unplaced components will appear next to the button for enabling «Design mode» (Figure 48).



Figure 48 – Indicator showing the number of unplaced components

To place a component, you need to be in «Design mode» and drag the component card onto the robot chassis. After the component is correctly placed, the card disappears from the panel. If no cards remain in the panel, the panel disappears.

The user can also click the «Delete» button located in the upper right corner of the card. After clicking, the card is deleted, and the corresponding component is also deleted.

4.9 Challenge intermediate results panel

The Challenge intermediate results panel provides data on the current state of the participant's progress through the challenge (Figure 49). The panel appears only if challenge tasks are placed in the scene.



Figure 49 – Challenge intermediate results panel

Challenge status (1 in figure 49) — shows the relative current state of progress (Figure 50).

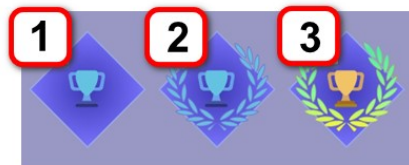


Figure 50 – Challenge status states

If the participant has not yet completed the challenge, the status is in state (1 in figure 50). If the participant has successfully completed the challenge, the status changes to state (3 in figure 50). If the participant decides to retry but the attempt is worse than the previous one, or they are in the process of improving their results, the status is in state (2 in figure 50).

RB collected (rating points) (2 in figure 49) — the field displays the current number of points earned during the attempt relative to the maximum number of points for required tasks or the passing score. Next to it, the best result of the attempt achieved by the participant during the challenge is shown. If the result is equal to or exceeds the passing score, the result is shown in green. Otherwise, it is shown in red.

Tasks completed (required) (3 in figure 49) — the field displays the current number of completed required tasks relative to the maximum number. Next to it, the best result of the attempt achieved by the participant during the challenge is shown. If the result is equal to or exceeds the passing score, the result is shown in green. Otherwise, it is shown in red.

Side tasks completed (4 in figure 49) — the field displays the current number of completed side tasks relative to the maximum number. Next to it, the best result of the attempt achieved by the participant during the challenge is shown. If the result is equal to or exceeds the passing score, the result is shown in green. Otherwise, it is shown in red.

«Finish» button (5 in figure 49) — allows the participant to complete the challenge. The button is displayed only in challenge completion mode. When creating or editing a challenge, the button is absent.

4.10 «Challenge briefing» panel

The «Challenge briefing» panel is intended to familiarize participants with the challenge conditions (Figure 51). The challenge begins with this panel.

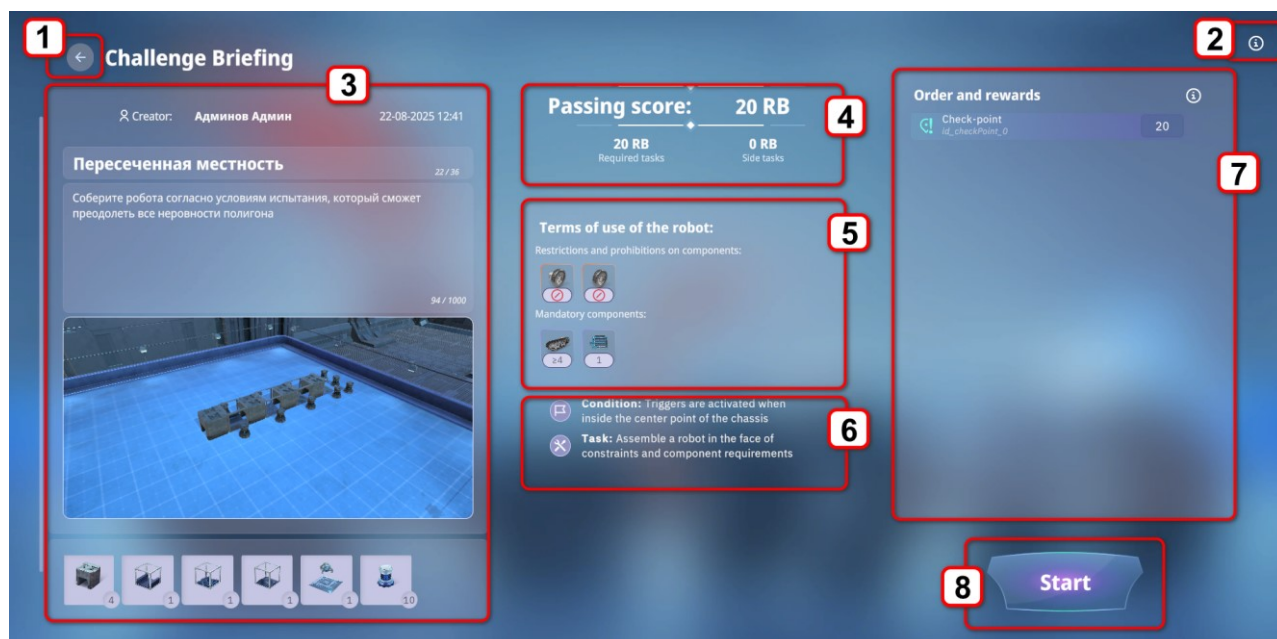


Figure 51 – «Challenge briefing» panel

«Back» button (1) — returns the user to the previous screen.

«Hint» button (2) — opens a hint window describing the user's interaction with this panel (Figure 52).

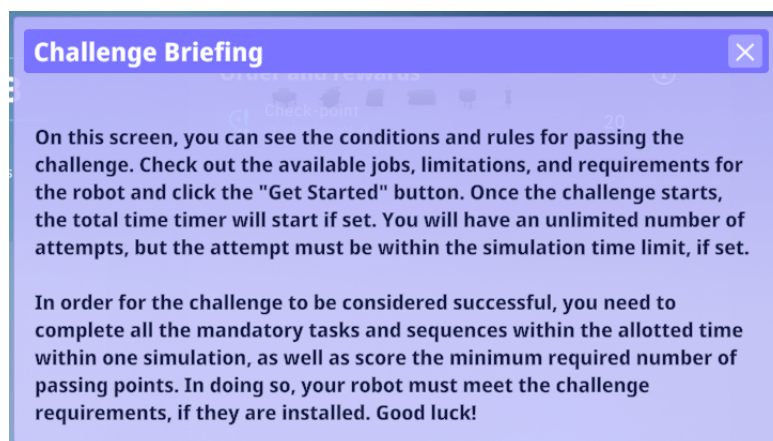


Figure 52 – Hint for the «Challenge briefing» panel

Challenge card (3) — the panel contains information about the name and description of the challenge, as well as an image of the polygon, the robot, and its wiring diagram.

Challenge points (4) — information about the passing score, the sum of points for required and side tasks.

Terms of use of the robot (5) — information about the rules for using the robot in the challenge, possible restrictions and requirements concerning robot components. If the participant needs to use their own robot («Bring» mode), a text field appears under the conditions to paste a link to their robot. The appearance is shown in figure 53.

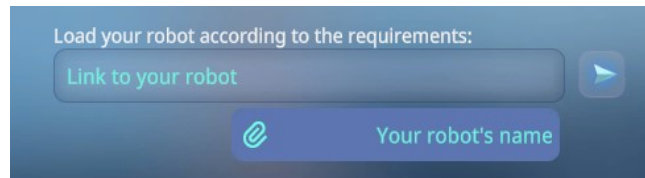


Figure 53 – Text field for loading a robot via link

Set of general conditions and tasks (6) — a list of conditions and tasks related to the challenge completion process.

Order and Rewards (7) — information about the number, sequences, «cost», and required status of tasks.

«Start» button (8) — takes the participant to the challenge scene. If the panel is used for a brief preview or the user's robot has not been loaded, the button is locked (lock icon).

4.11 Successful attempt completion panel

The panel appears as soon as the challenge participant has completed all required tasks of the challenge or reached the passing score (Figure 54).

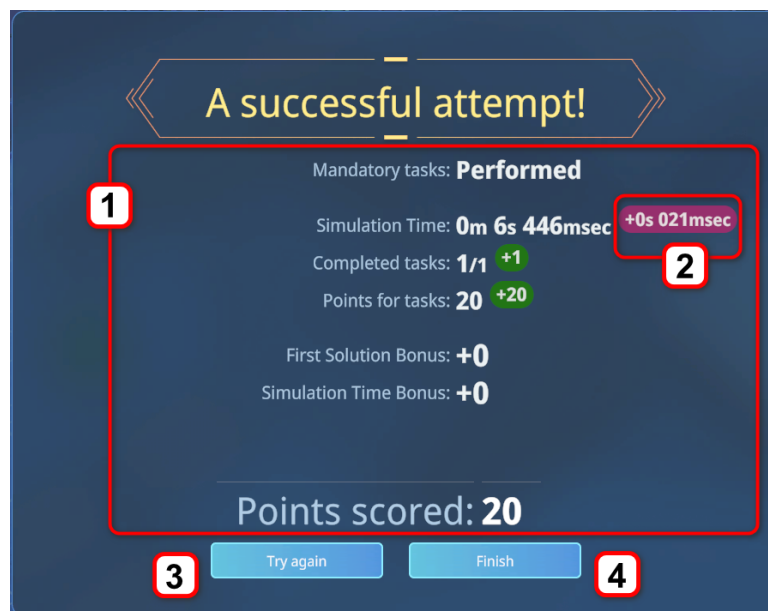


Figure 54 – Successful attempt completion panel

Attempt statistics and points scored (1) — an information panel describing the results of the participant's successful attempt.

If this is not the participant's first successful attempt, the statistics are **automatically compared** with the best attempt within the current challenge (2). If the result of the current attempt differs from the best one, a comparison is shown next to the parameter in green (in case of improvement) or red (in case of worsening).

The buttons at the bottom of the panel differ:

– When completing a challenge:

- **«Try again» button (3)** allows starting a new attempt to improve the result. When clicked, the panel closes and the participant can start a new simulation session.

- «**Finish**» button (4) completes the challenge and takes the participant to the challenge completion panel.
- When creating a challenge:
 - «**Continue editing**» and «**Save**» buttons, allowing to return to editing or save the changes made.

4.12 Challenge completion panel

The challenge completion panel appears after successfully completing the challenge or when time runs out without any successful attempts. The appearance of positive and negative challenge outcomes is shown in figures 55 and 56.

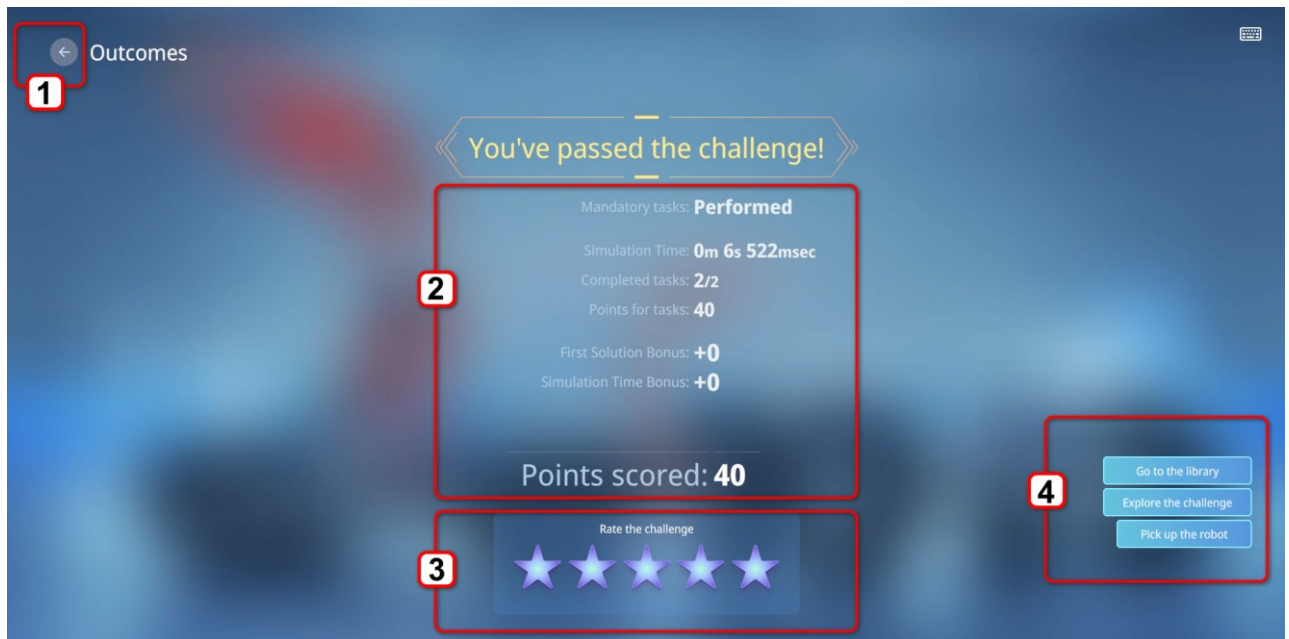


Figure 55 – «Results» panel in case of successful completion

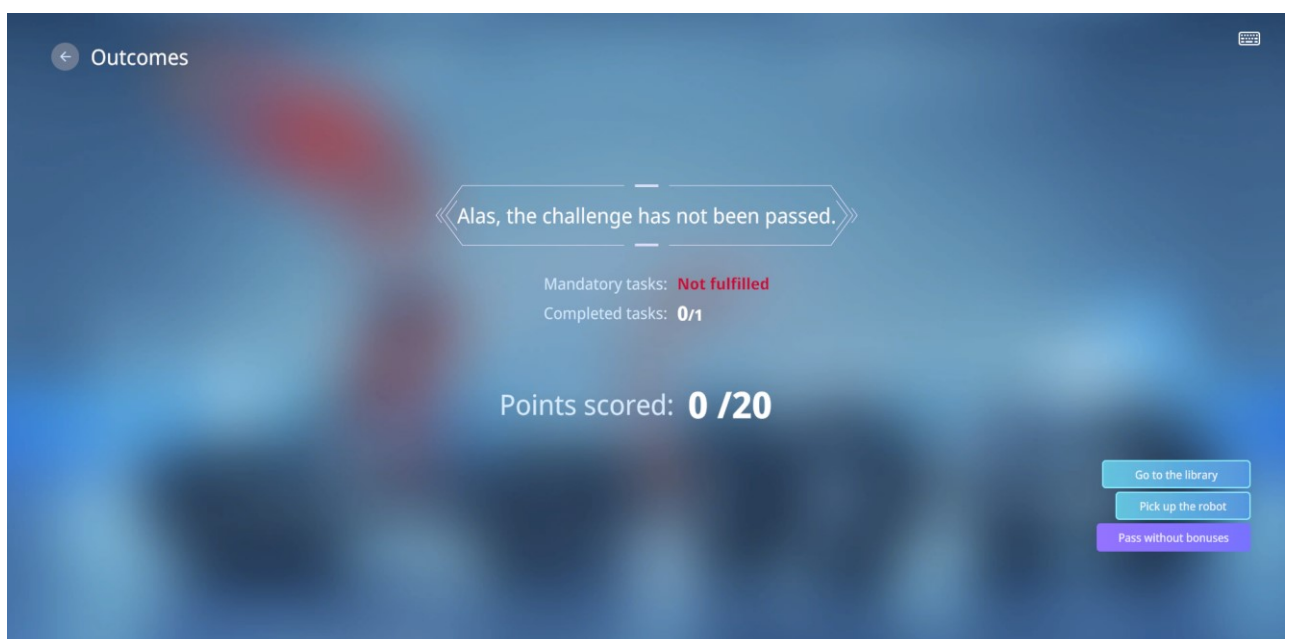


Figure 56 – «Results» panel in case of challenge failure

Clicking the «**Back**» button (1) returns the participant to the «Resource Library».

Completed challenge statistics (2) contain the results of the best attempt in case of successful completion, regardless of the success of that attempt.

After completing the challenge, the user can **rate the challenge** (3) by clicking one of the five star icon buttons.

Depending on the outcome, **additional buttons** are available at the bottom of the panel (4):

- In case of successful completion:
 - «Go to library» — returns to the resource library.
 - «Explore the challenge» — opens the challenge scene, which displays all components placed by the author. The opened scene can be saved. When saving, the scene author is the same as the original challenge.
 - «Pick up the robot» — saves the robot assembled during the challenge to the «Robot Library».
- If the challenge was not completed:
 - «Go to library» — returns to the resource library.
 - «Pass without bonuses» — restarts the challenge in a mode where the total time of previous attempts is not taken into account, and points for the first solution are not awarded. The button is available only outside the tournament (it is not displayed in tournament mode).
 - «Pick up the robot» — saves the robot assembled during the challenge to the «Robot library». Available only if the robot was assembled by the user themselves.

5 Scene interaction

While the user is in the scene, the following interactions with three-dimensional objects are available:

- **Panning** (camera movement) — moving the cursor while holding down LMB (left mouse button) or MMB (middle mouse button), or dragging the screen with a finger on a touch surface.
- **Zooming** (camera zoom in/out) — scrolling the mouse wheel up (zoom in) or down (zoom out), «spread»/ «pinch» gestures for touch surfaces.
- **Camera rotation** — moving the cursor while holding down RMB (right mouse button), or dragging the screen with two fingers on a touch surface.

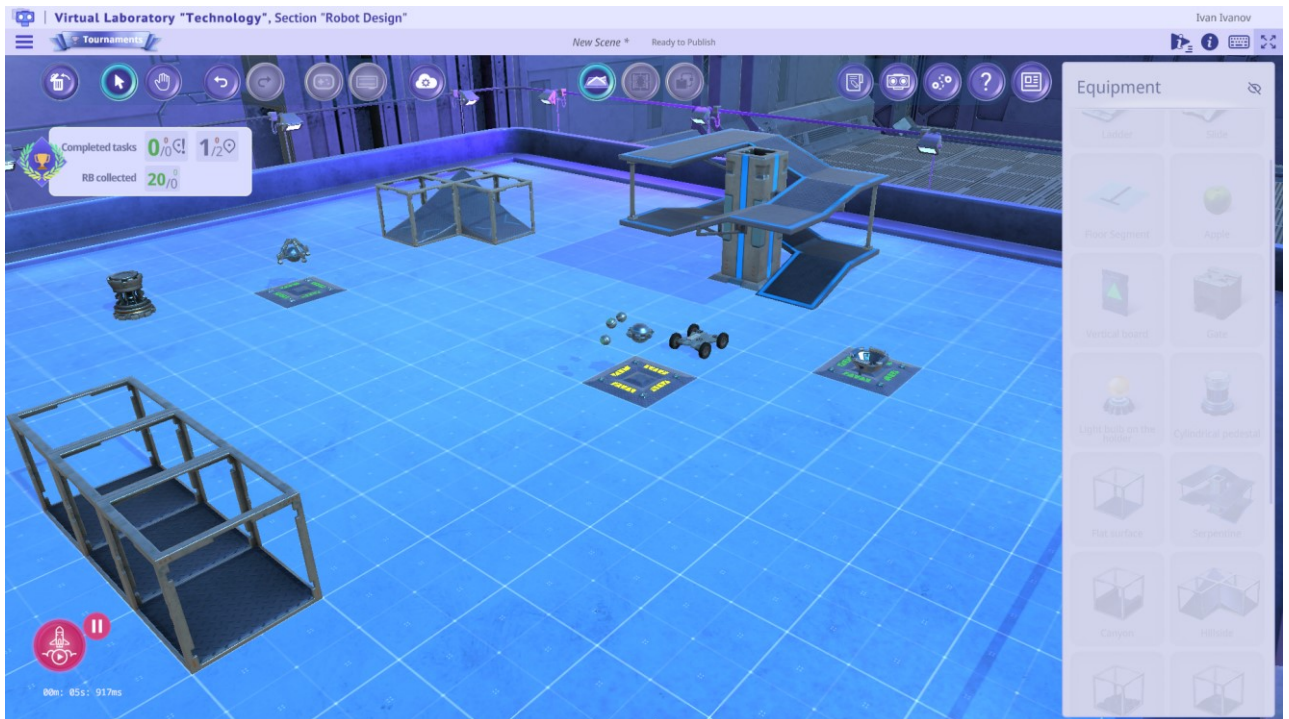


Figure 57 – Three-dimensional challenge scene

6 Resource library

The «Resource Library» is designed to store three types of resources: scenes, polygons, and robots. These resources can be created either by the user themselves or by other users who have provided access to their third-party resources.

6.1 Scene and challenge library

The «Scene and challenge library» provides the user with access to scenes and challenges created by the user or available to them (Figure 58). Access to the «Scene and challenge library» is through the internal application menu using the «Scenes and challenges» item (Figure 4).

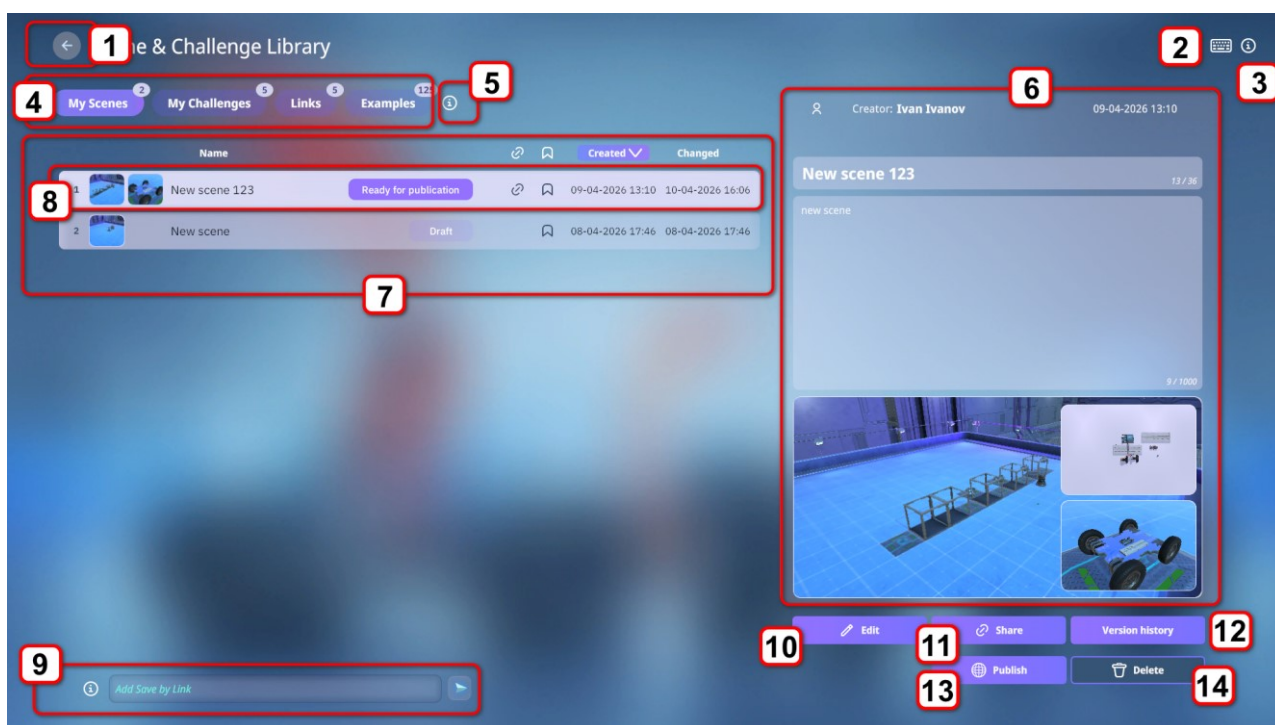


Figure 58 – «Scene and challenge library»

The «**Back**» button (1) returns the user to the three-dimensional scene.

When the on-screen **keyboard activation button** (2) is clicked, the application will invoke the on-screen keyboard each time the user interacts with character or numeric input fields. It is recommended to use this setting when working with touch screens.

The **button for calling the general hint** (3) opens a panel with hint text describing the general principles of interacting with the «Resource Library» screens (Figure 59).

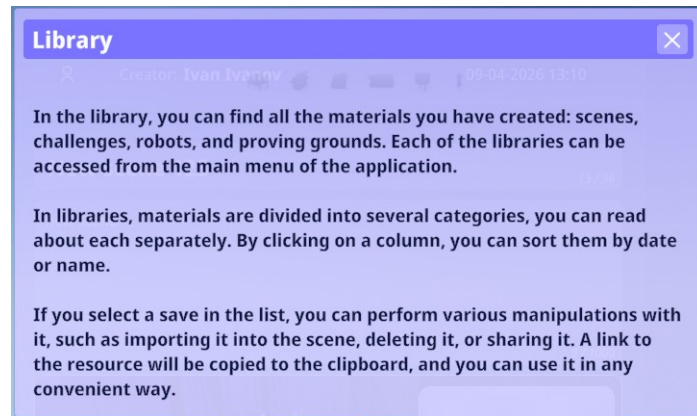


Figure 59 – Hint for the «Scene and challenge library» screen

The «Scene and challenge library» sections panel (4) contains a list of buttons. When a button is clicked, the corresponding section opens, containing records stored on the server.

When the **button for calling the hint on sections** (5) is clicked, a panel appears with hint text describing interaction with the «Scene and challenge library» sections (Figure 60).

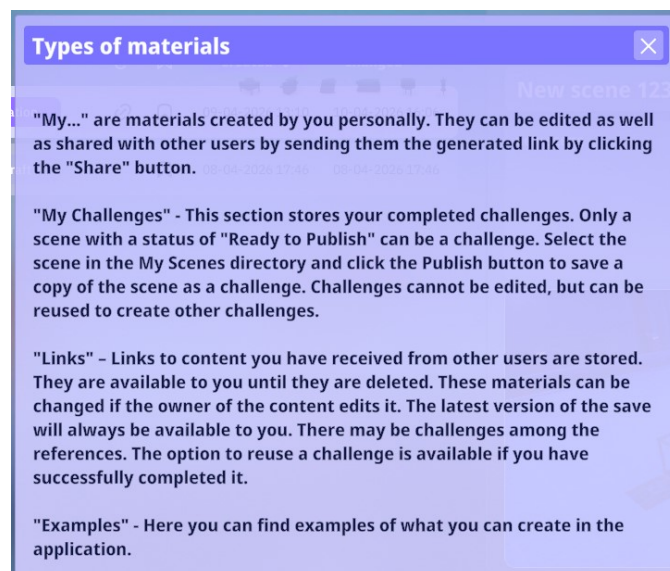


Figure 60 – Hint on the «Scene and challenge library» sections

The **scene/challenge card** (6) contains information about the creator, the last editor of the scene or challenge, the date of creation and last modification, as well as the name, description, and a set of graphical images of the polygon, the robot, and its wiring diagram.

The **list of records** (7) contains the scene/challenge records available to the user. The user can sort the list by a number of record attributes by clicking on the corresponding column header:

- «Name» — alphabetical sorting by name.
- «Created» and «Changed» — sorting by creation and modification date.
- «Flag» («In favorites») — favorite records are at the top of the list (newest first, then older), then non favorites.
- Checkmark («Passed») — for the «Links» and «Examples» sections: first newly passed, then newly not passed.
- Star («Rating») — from highest rating to lowest (available in the «My Challenges», «Links», and «Examples» sections).

A **scene/challenge record** (8) corresponds to a created and saved scene or challenge. The record contains fields such as name, small image of the polygon and robot, scene/challenge status, link generation attribute, attribute of being added to favorites by the current user, as well as the dates of last modification and creation. When a record is clicked, the data of the selected record is displayed in the **scene/challenge card** (6).

The **text field for loading a saved scene/challenge via link** (9) allows access to a resource created by another user. When a link generated by the application is pasted into the text field and the «Apply» button (located to the right of the text field) is clicked, the resource is added to the «Links» section. When the hint button (located to the left of the text field) is clicked, a panel appears on the screen with hint text on how to use the text field.

When the «**Edit**» **button** (10) is clicked, the three-dimensional scene of the selected scene record opens, which the user can edit.

When the «**Share**» **button** (11) is clicked, the application automatically creates a hyperlink that the user can give to another user to grant access to the selected resource. The hyperlink text is copied to the operating system clipboard. The user is notified of the result via a push notification.

When the «**Version history**» **button** (12) is clicked, a panel opens with a list of the last 10 saved versions of the challenge: clicking on a version highlights it, and double-clicking or pressing the button  loads the selected version of the polygon as a new unsaved scene, while the name and description are kept from the original scene (Figure 61).

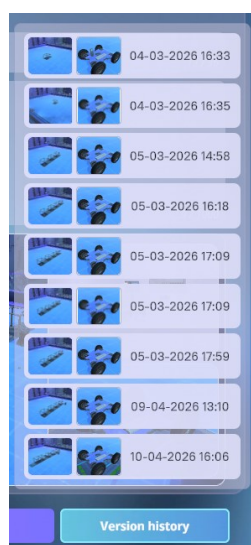


Figure 61 – «Version history» panel

When the «**Publish**» **button** (13) is clicked (available only for scenes with the “Ready to Publish” status), the scene is converted into a challenge, and its record is moved to the corresponding section of the library.

When the «**Delete**» **button** (14) is clicked, the application asks the user to confirm their intention. When the appearing «Delete» button is clicked, the scene will be permanently deleted. The appearance of the confirmation prompt is shown in figure 62.

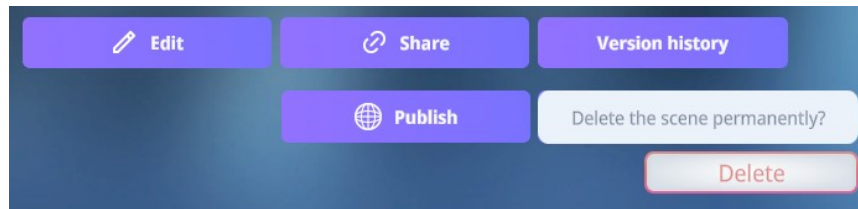


Figure 62 – Appearance of the confirmation prompt for deleting a scene/challenge

Depending on the library section, additional buttons are available to the user (Figure 63).

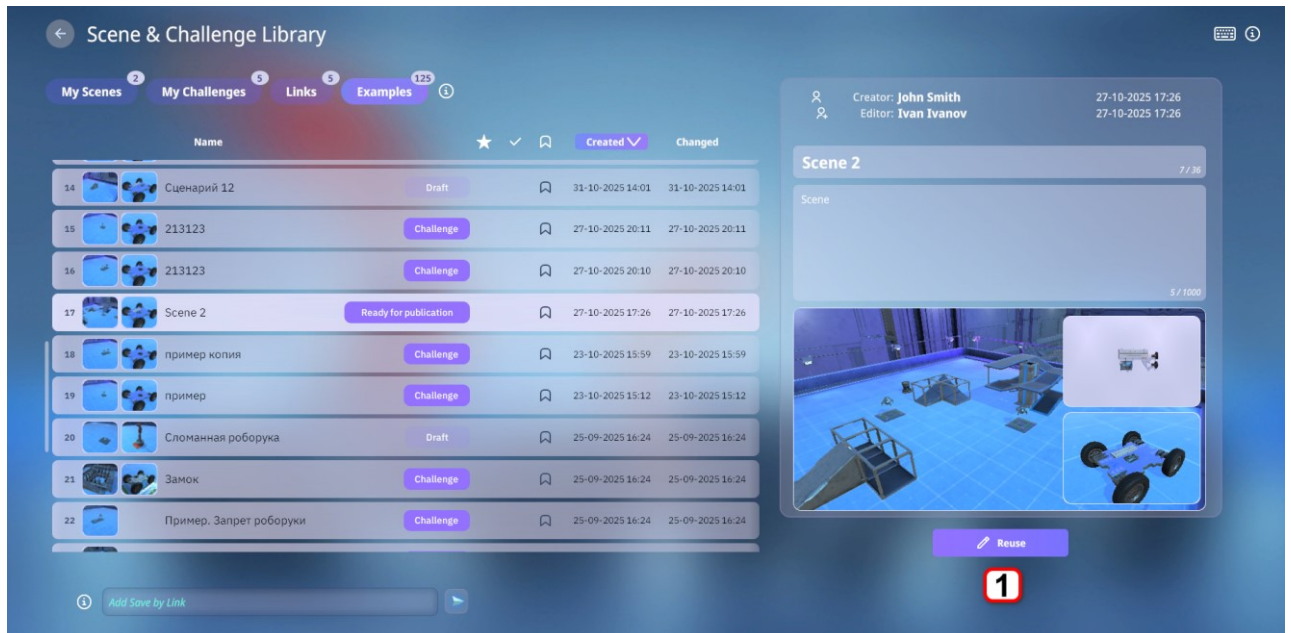


Figure 63 – Scene and challenge library, «Examples» section

The «**Reuse**» button (1) is available in the «Links» and «Examples» sections. When clicked, the selected challenge is loaded. If simulation was active, it is turned off. The current scene is replaced by the loaded challenge, and «Polygon mode» is enabled.

6.2 Polygon library

The «Polygon Library» provides the user with access to polygons saved by the user or available to them (Figure 64). Using this library, the user can replace the arrangement of interior components with a saved version. Access to the «Polygon library» is through the internal application menu using the «Import polygon» item (Figure 4).

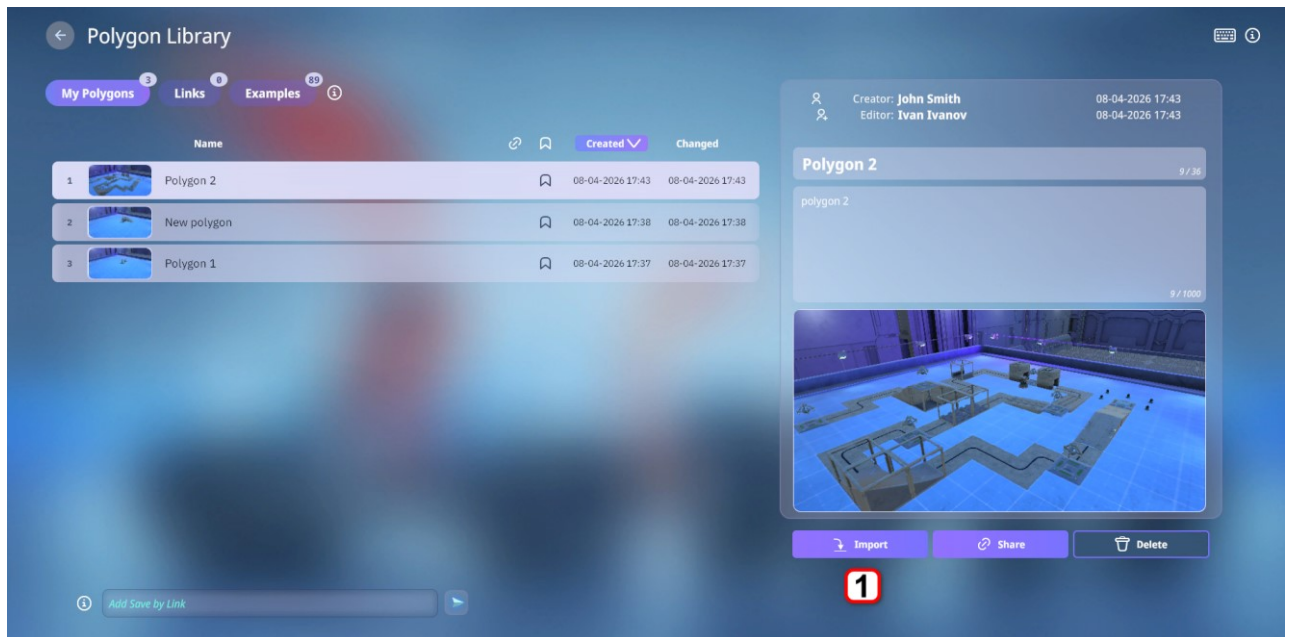


Figure 64 – Polygon library

Interface forms similar to the «Scene and challenge library» replicate the functionality.

When the **«Import» button** (1) is clicked, the set of interior components, including their settings, is automatically placed in the open scene.

6.3 Robot library

The «Robot Library» provides the user with access to robots saved by the user or available to them (Figure 65). Using this library, the user can place the selected robot in the scene or replace the current one. Access to the «Robot Library» is through the internal application menu using the «Import robot» item (Figure 4).

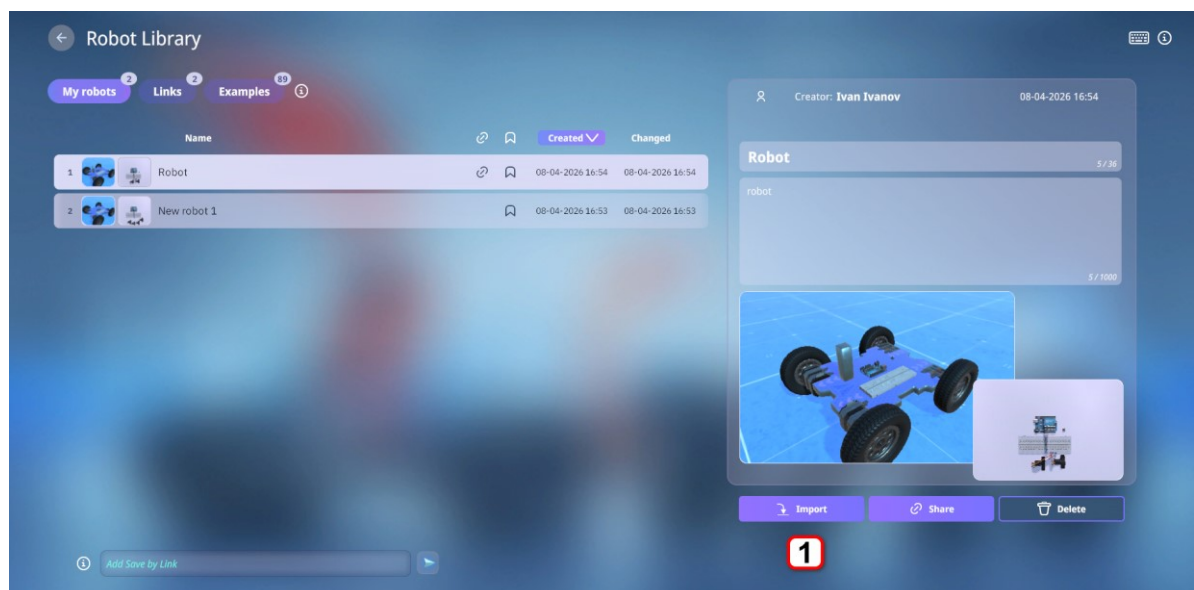


Figure 65 – Appearance of the «Robot Library»

Interface forms similar to the «Scene and challenge library» replicate the functionality.

When the **«Import» button** (1) is clicked, the selected robot, including its placement, microcontroller code, and wiring diagram, is automatically placed in the open scene.

7 Component description

7.1 General operations with components

The following describes operations common to all components placed in the workspace.

7.1.1 Moving

To move an object (component) in the workspace, drag it in the desired direction while holding down the LMB or continuing to press with a finger on a touch screen (Figure 66).

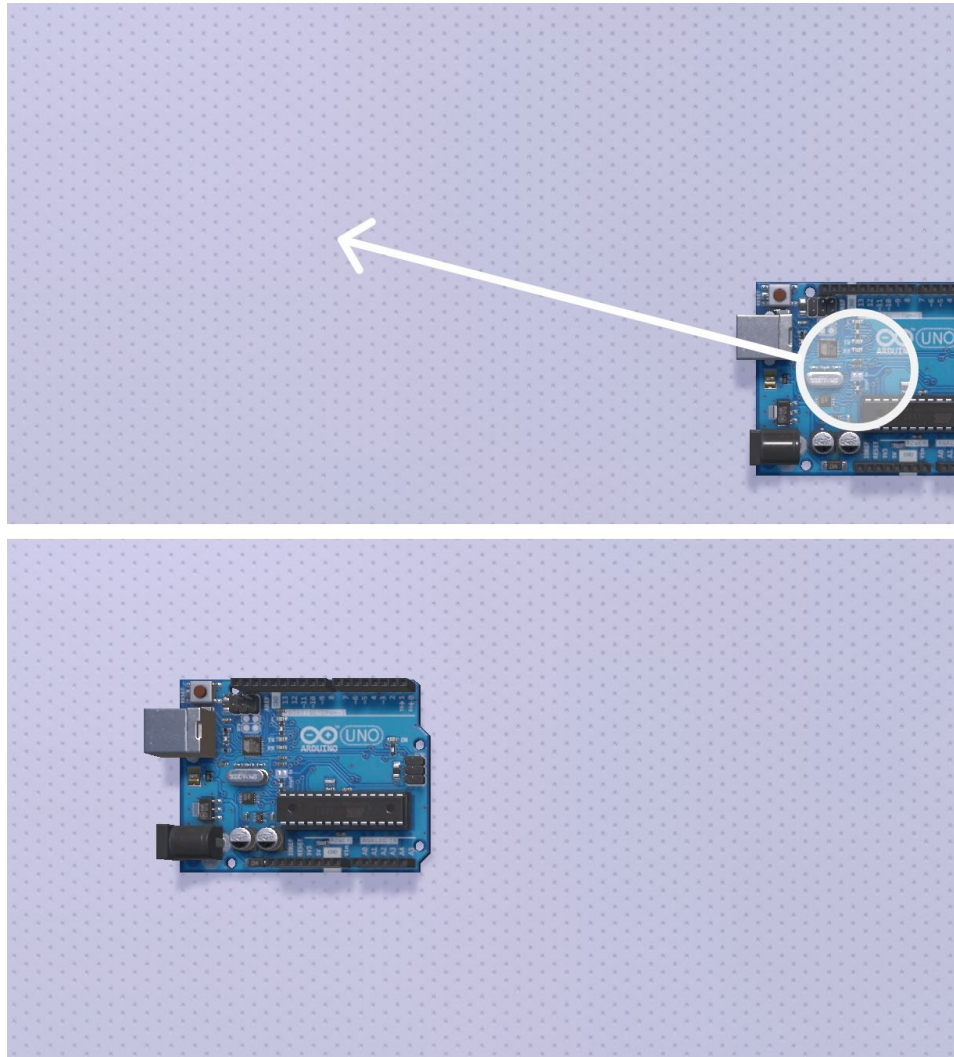


Figure 66 – Component dragging process

During dragging, it is possible to create a direct connection between components. To do this, drag the component so that its male pins (protruding conductors) visually touch the female pins (socket connectors) of another component. The most striking example of such interaction is placing components on a breadboard (Figure 67).

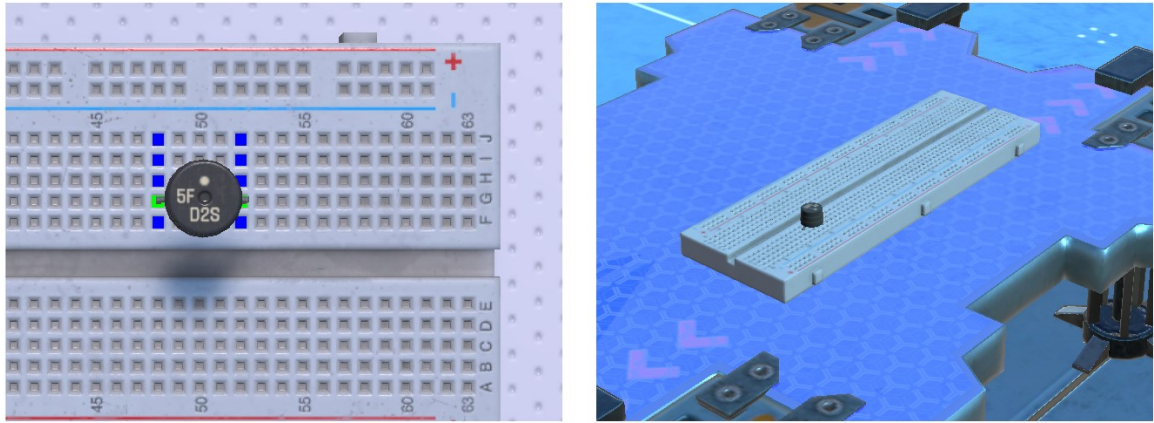


Figure 67 – Placing a component on a breadboard

7.1.2 Rotation

To rotate an object, the user must open the component's context menu.

7.1.2.1 Rotation in polygon mode

The component's context menu contains buttons that look like curved arrows.

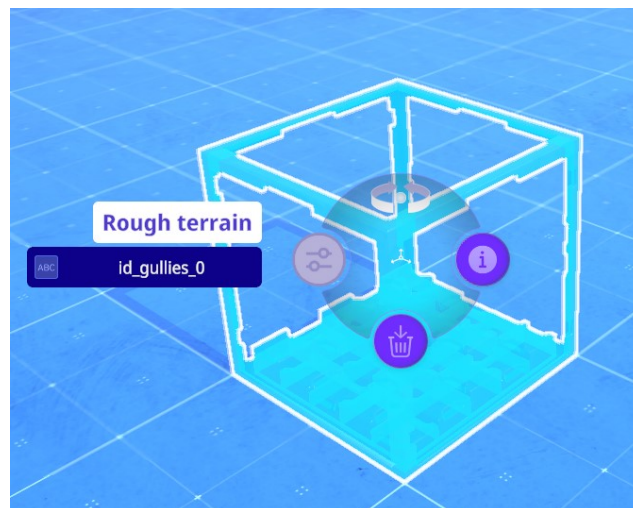


Figure 68 – Component context menu in polygon mode

When one of the two buttons is clicked, the component rotates by 90 degrees in the direction of the arrow.

7.1.2.2 Rotation in design mode and switching mode

The context menu contains a circle with notches defining the possible rotation angle, buttons that look like curved arrows, and a slider that moves along the circle.

The method of rotating the component depends on where it is placed (Figure 69):



Figure 69 – Component context menu in «Design mode» and «Switching mode»

- If the component is on the chassis, rotation in 15-degree increments is available. Each time an arrow button is clicked, the component rotates by 15 degrees in the corresponding direction. Dragging the slider along the circle allows you to set an arbitrary rotation angle, and the component automatically rotates to the value corresponding to the current slider position.
- If the component is placed on a breadboard, its rotation is limited to fixed positions marked by notches on the circle (for example, only angles multiples of 180 degrees are available). In this case, the buttons and slider allow switching between these allowed positions, and the component cannot be set at an intermediate angle.

7.1.3 Opening the context menu

The context menu is a tool for managing and viewing information about an object. It allows you to configure the component, view its description, or delete it.

To open the context menu, click on the object. The context menu then appears (Figure 70).

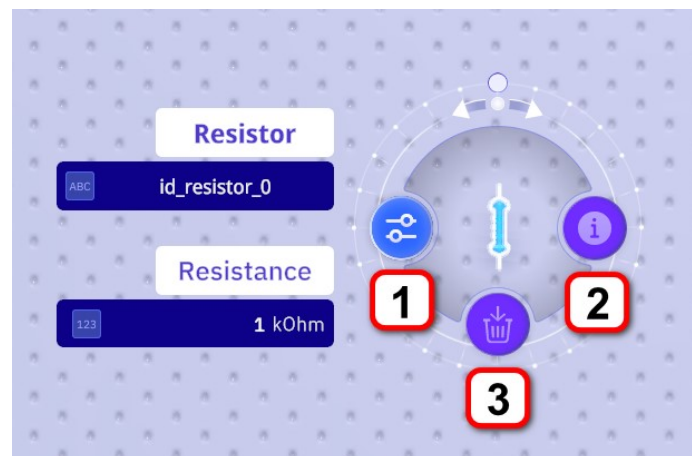


Figure 70 – Component context menu

The context menu is a circle containing the following buttons:

- button for calling component parameters (1);
- button for calling the component info panel (2);
- button for deleting the component (3).

Note: For the Arduino board, the parameters button (1 in figure 71) is replaced by a button for calling the code panel, which opens the executive program editor (Figure 71).

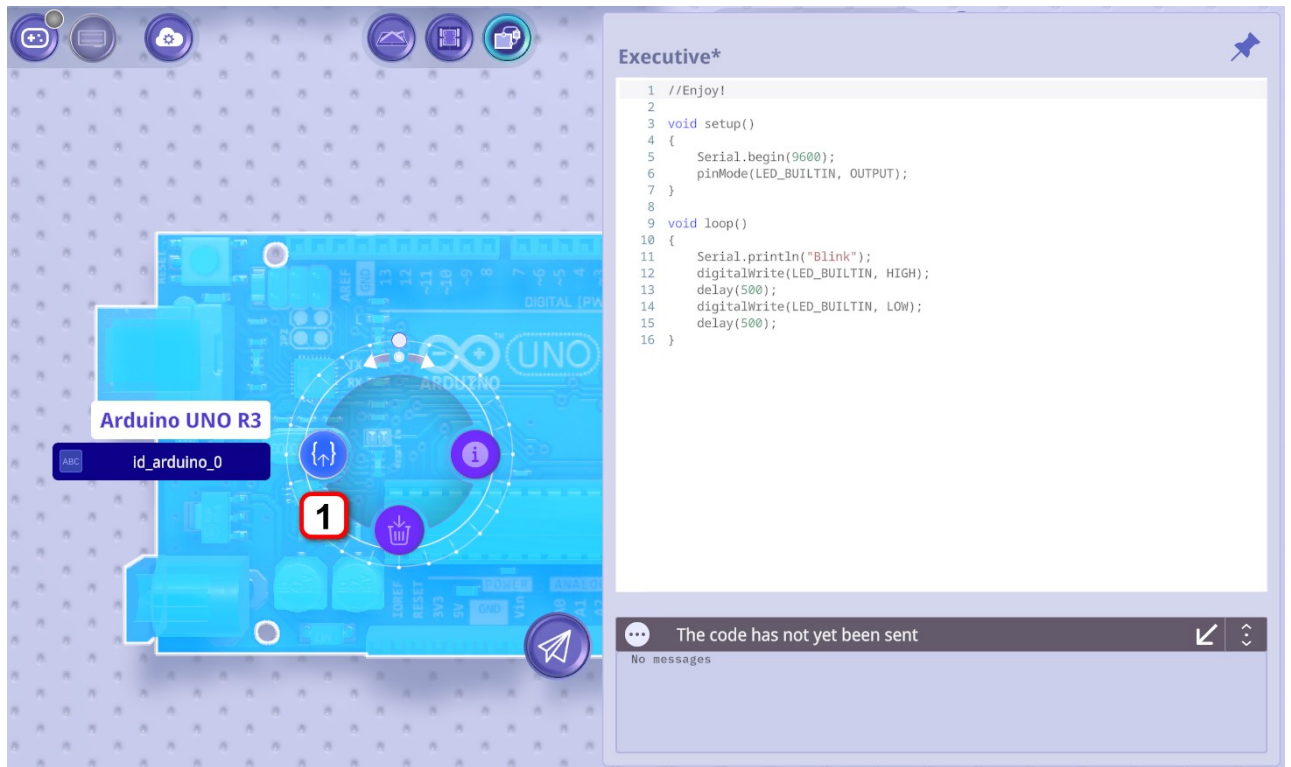


Figure 71 – Arduino board context menu

When the **component parameters button** is clicked, the corresponding settings panel for the selected component opens. The types of settings and their graphical representation are described in figure 72.

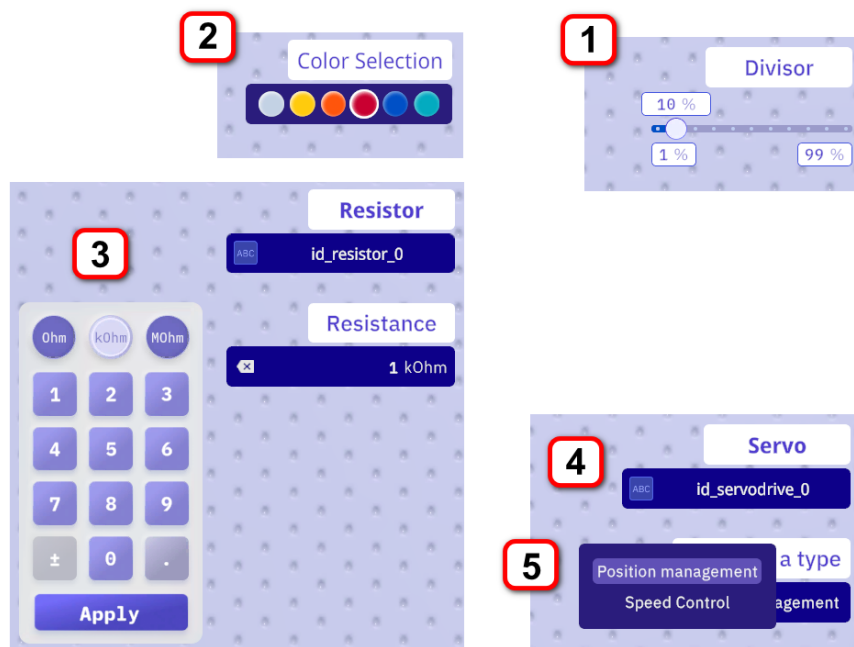


Figure 72 – Types of graphical representation of object parameters

Component parameters are divided into four types:

- slider setting (1) — allows changing the parameter value;
- color selection (2) — opens a palette for changing the component's color;
- numeric field value setting (3) — switching between preset options;
- text field (4) — displays and allows editing of the component identifier;

- mode or additional parameter selection (5) — a drop down list or switch for setting the operating mode.

To interact with types (3) and (4), you must first click on the field containing the value.

For type (4), the user can invoke the on-screen keyboard to enter a value or use a physical keyboard. The field retains any value entered by the user. Pressing the «Enter» key or clicking on an empty area of the workspace will finish input.

For type (3), when the field is selected, a numpad is automatically displayed for entering a numeric value. In this case, the user can also use the numeric segment of a physical keyboard for input. Clicking the «Apply» button or the «Enter» key will successfully complete input if a valid value has been entered. Otherwise, the field content is highlighted in red, and the «Apply» button becomes inactive. If the user deselects the field, an invalid entered value will not be saved — the field will revert to its previous valid value.

To change values of types (1) and (2), the user simply clicks on the desired option.

To change values of type (5), the user first clicks on the parameter value, then selects the desired value from the drop-down menu.

Clicking the **button for calling the component info panel** provides access to the basic description of the object. When clicked, an info panel appears next to the sector (Figure 73).

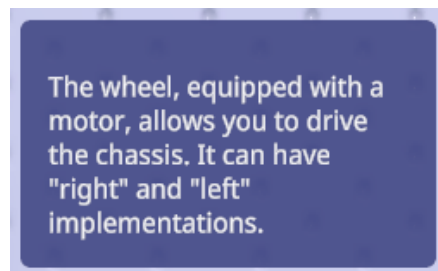


Figure 73 – Component info panel

If the selected component has no modifiable settings, the context menu will contain two sectors. In this case, the info sector is selected by default.

Clicking the info panel button again hides the panel.

Clicking the component **delete button** removes the component from the workspace. If the user wants to delete an Arduino Uno component whose code input panel already contains information, additional confirmation will be requested (Figure 74).



Figure 74 – Confirmation of deletion

If the selected component with an open context menu is outside the screen, an arrow pointing to it appears near the screen edge. Clicking the arrow centers, the screen on the selected object.

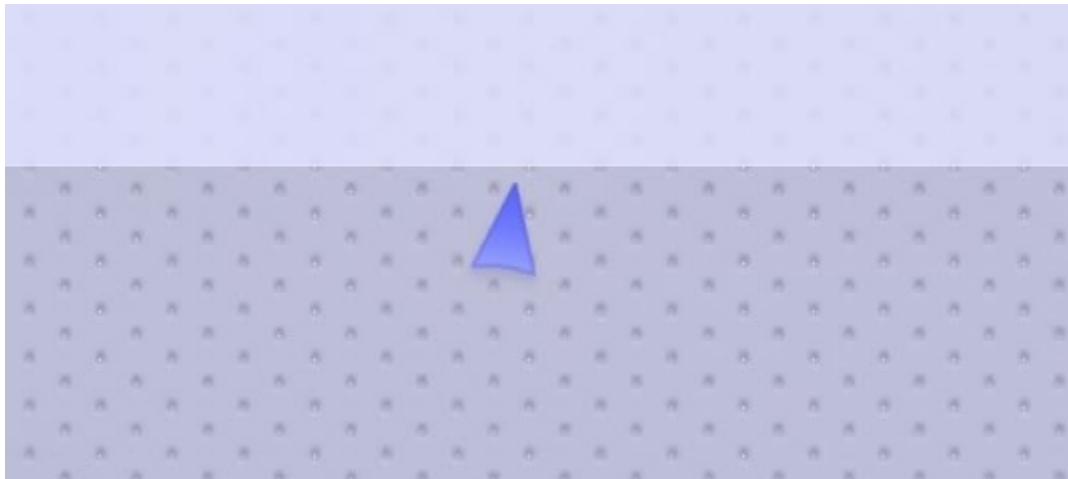


Figure 75 – Arrow pointing to the selected object

7.1.4 Connecting via pins

Connecting components with wires is the only way to build an electronic circuit and allow electric current to flow through its elements.

To start creating a connection, click on a component pin. A label with the pin name and a cancel selection button appears next to the pin (Figure 76).



Figure 76 – Selecting the starting pin

Then select the pin to which the connection will be made. As soon as the pin is selected, the wire is automatically drawn to it (Figure 77). A special algorithm allows connections to be routed around components already placed in the scene.

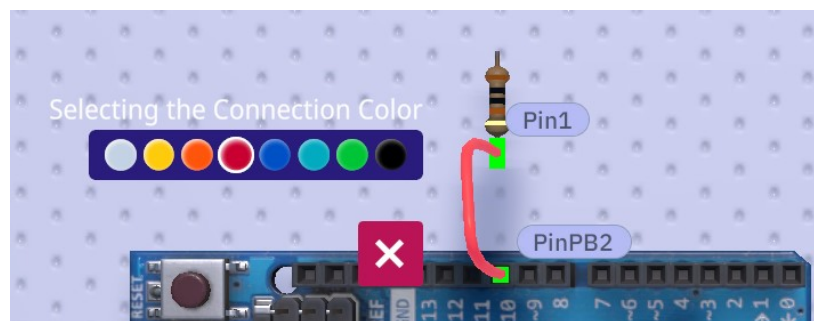


Figure 77 – Forming a connection

Next to the pin to which the wire is connected, there is a color selection panel and a button for deleting the created wire. Color selection allows you to visually mark connections according to their role in the circuit, making it easier to read the schematic and quickly navigate the connections. The created wire can be selected just like any other object in the workspace.

7.2 Interior components

Interior components are designed to create a track for the robot and a set of tasks that the participant will need to complete during the challenge. Interior components are available in «Polygon mode».

7.2.1 Ladder

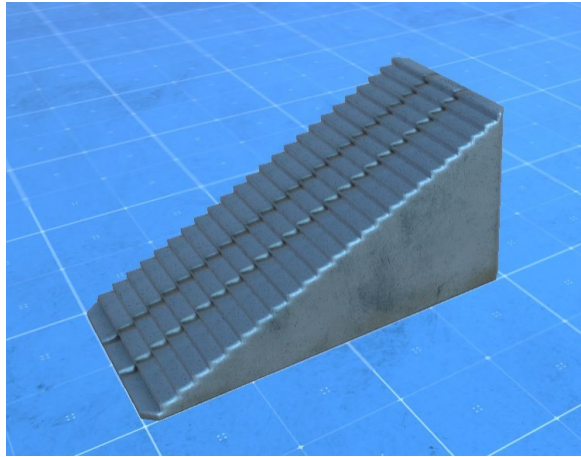


Figure 78 – Ladder

A ladder is an interior component of the polygon that provides a rise to a given height and is equipped with a set of steps.

The user can adjust the height of the ladder within the allowable range.

7.2.2 Slide

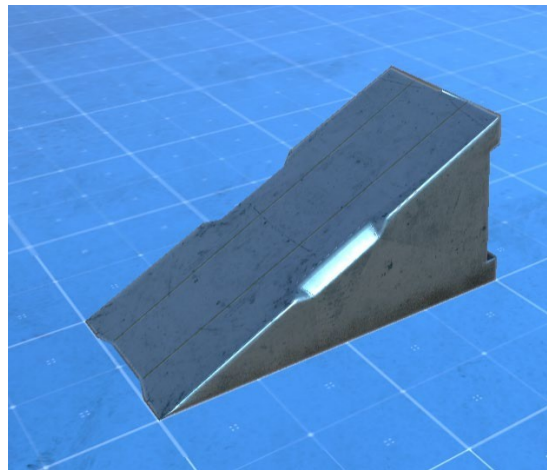


Figure 79 – Slide

A slide is an interior component of the polygon that provides a rise to a given height at a fixed angle of inclination of the lifting surface.

The user can adjust the height of the slide within the allowable range.

7.2.3 Floor segment

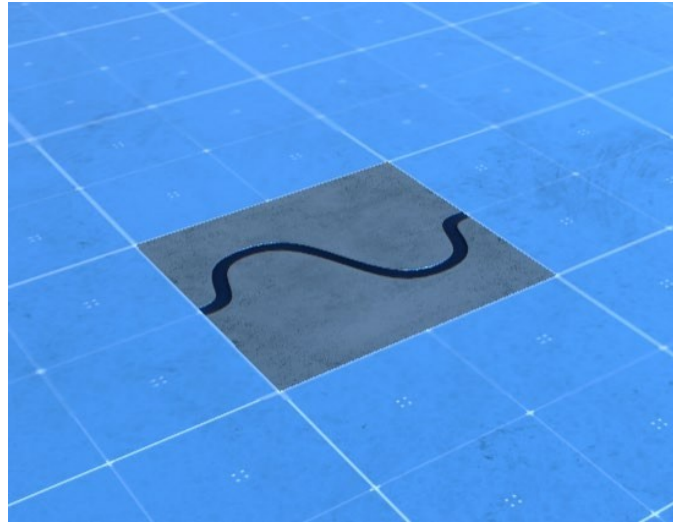


Figure 80 – Floor segment

The component is a polygon flooring cell with a set of markings that allow creating a track for a robot configured for color recognition.

The user can select various marking options from the provided set.

The user can also place the component not only on the floor but also on a number of horizontal flat surfaces of other interior components.

7.2.4 Apple



Figure 81 – Apple

The component is intended for placement on the polygon and can perform the functions of a territorial marker. A mobile manipulator or a Robohand can also interact with it.

The user can select different component colors from the provided set.

7.2.5 Vertical board

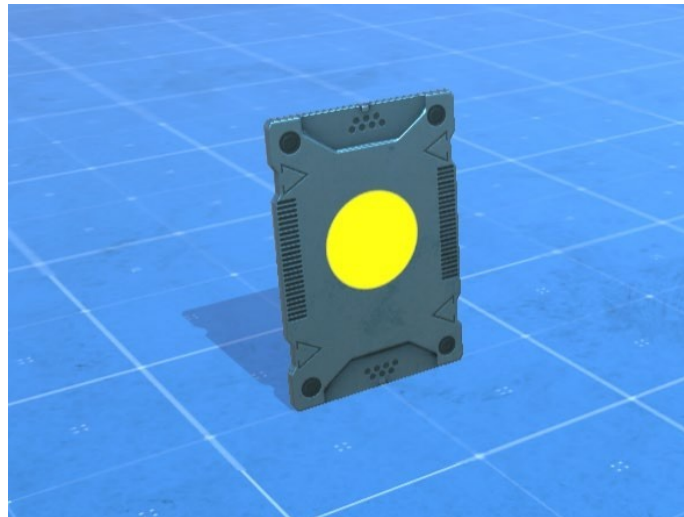


Figure 82 – Vertical board

The component is a vertical panel with a symbol applied to one side.

The user can select the shape and color of the symbol from the provided set of options.

7.2.6 Gate



Figure 83 – Gate

A gate is a component that bounds the space from the sides and from the top. A robot passing through the gate must fold the mobile manipulator and have suitable geometric dimensions.

The user can set different gate opening sizes from the provided set of options.

7.2.7 Light bulb on the holder



Figure 84 – Light bulb on the holder

A light bulb on the holder is a light-emitting component with variable intensity and color.

The user can set the intensity level of the emitted light within the available range and choose its color from a set of options.

7.2.8 Cylindrical pedestal



Figure 85 – Cylindrical pedestal

The component is intended for placing a number of other objects on it. The user can change the height of the component within the available range.

7.2.9 Flat surface

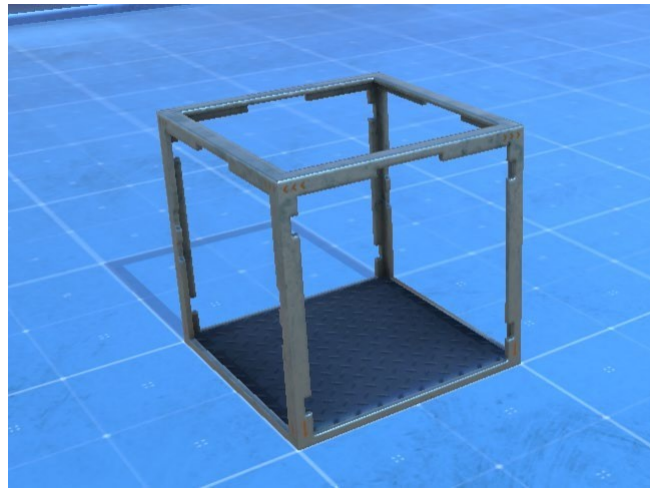


Figure 86 – Flat surface

A polygon segment with a flat surface. It can be used as an auxiliary object or as a means of creating multiple levels on the polygon.

7.2.10 Serpentine

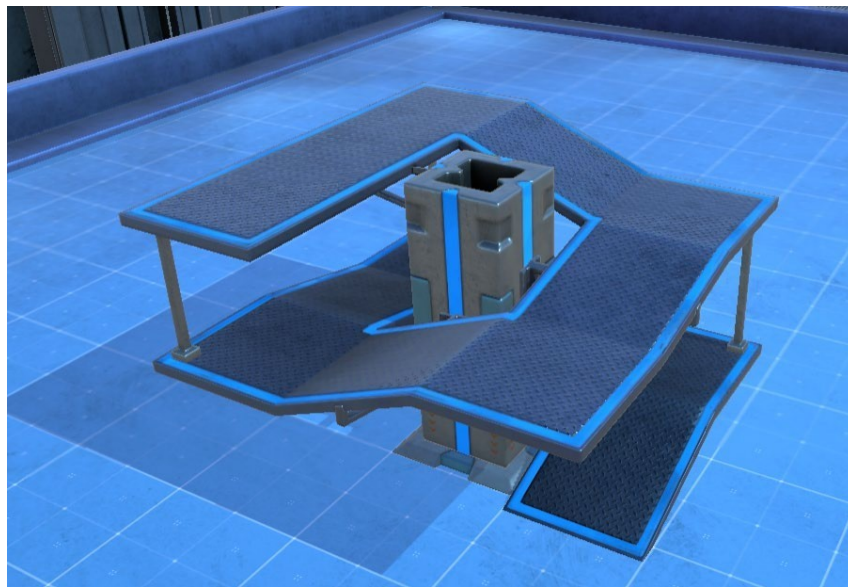


Figure 87 – Serpentine

The serpentine is a polygon segment with increased difficulty of passage. It is shaped like a stylised spiral with a gradual rise in height. The robot is tested for orientation on a narrow winding section of road that has a variable slope and lacks guard structures to prevent possible falls.

7.2.11 Canyon

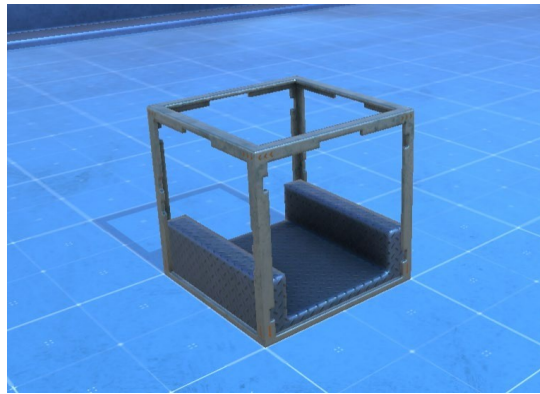


Figure 88 – Canyon

A canyon is a narrow section of a polygon bounded on two sides. The robot is tested for stability of behavior within a limited space.

7.2.12 Hillside

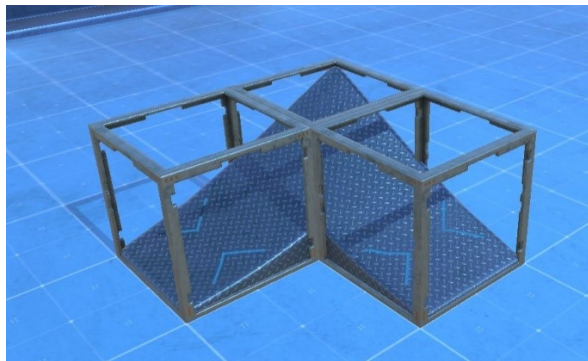


Figure 89 – Hillside

A hillside is a surface with a changing angle of inclination.

7.2.13 Rough terrain

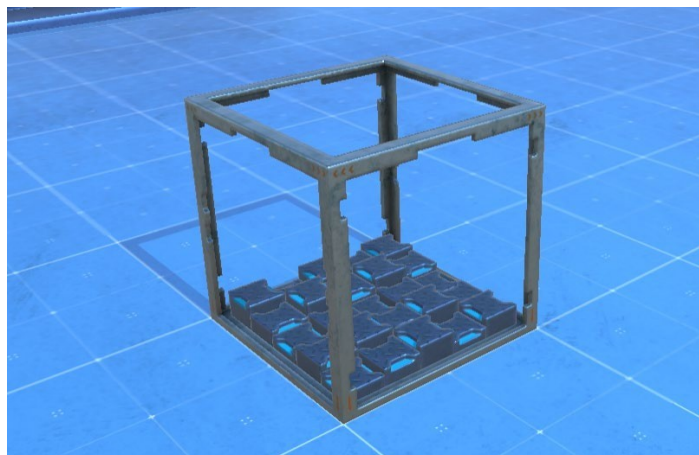


Figure 90 – Rough terrain

Rough terrain is a flat, impassable section of the polygon. The robot is tested for its ability to climb low vertical hills and overcome a surface with sharp changes in height.

7.2.14 Bumpy road

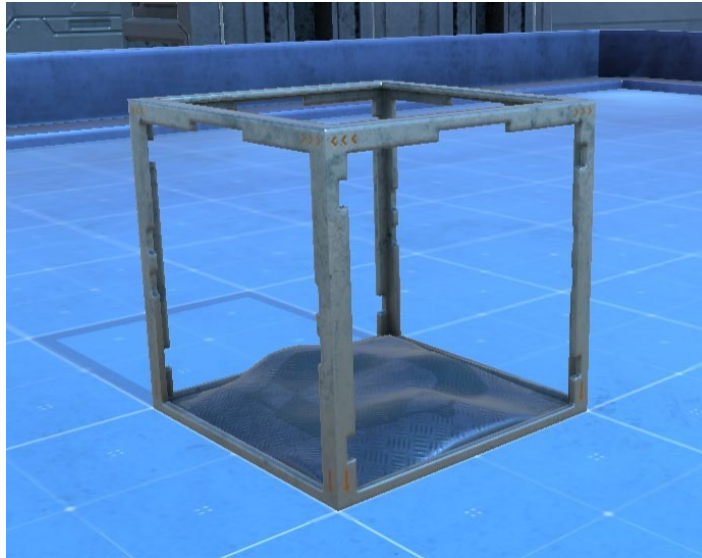


Figure 91 – Bumpy road

A bumpy road contains several smooth bumps that imitate stones or unevenness of the ground. The robot is tested for stability of behavior during tilts along the transverse axis.

7.2.15 Start

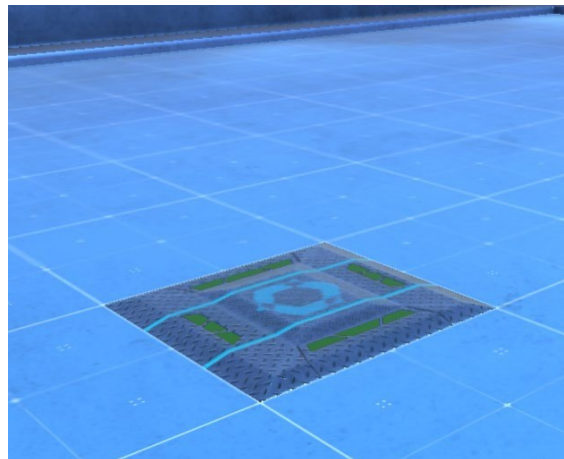


Figure 92 – Start

A component specifically designed for conducting a challenge. If the component is placed in the scene, at the start of the simulation the robot is always located in the center of this component.

7.2.16 Check-point



Figure 93 – Check-point

A component specifically designed for conducting a challenge. To complete the task associated with this component, the robot must drive through its platform. The setting of the task's «cost» in points is determined in the challenge conditions panel, section «Order and rewards».

7.2.17 Basket



Figure 94 – Basket

A component specifically designed for conducting a challenge. The way to complete the task associated with the «Basket» is to place the required component into its bowl. The user can select a specific component of the «Apple» type from those placed on the polygon. Like the «Check-point», it has a «cost» in points when completing the challenge.

7.3 Robot chassis

The chassis is the basic element when creating a robot. Chassis components can be selected and placed in polygon mode.

7.3.1 Robohand



Figure 95 – Robohand

The component is the basis for designing a stationary robot that cannot move around the polygon. The chassis has built-in servos that drive the manipulator when controlled using the Arduino Uno R3.

7.3.2 Chassis (mobile robot)

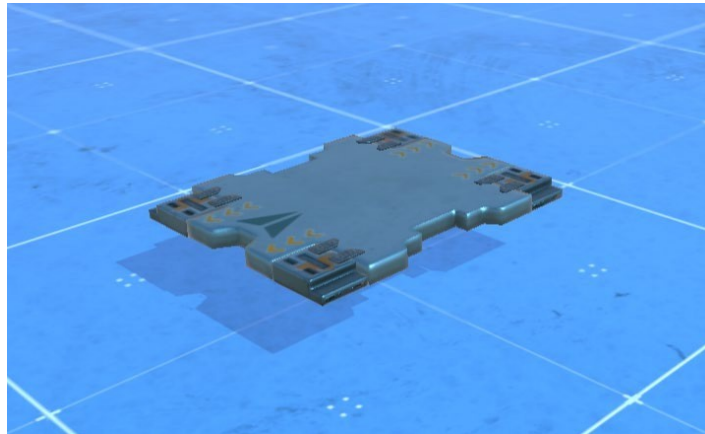


Figure 96 – Chassis (mobile robot)

The chassis is the basis for designing a mobile robot capable of moving around the polygon. It has four slots for installing components: «Wheel», «Wheel with motor», «Caterpillar with motor».

Additional components from the following categories can be placed on the chassis:

- mechanical and structural components (see [7.4 «Mechanical and structural components»](#));
- sensor components (see [7.5 «Sensor components»](#));
- electronic components (see [7.6 «Electronic components»](#)).

Changing the geometric dimensions of the chassis is only available in «Design mode». The user can set the dimensions within the allowable ranges.

7.4 Mechanical and structural components

Mechanical and structural components are used to ensure the robot's mechanical interaction with the three-dimensional polygon and to provide surfaces for placing other components. Components from this set are available in robot design mode and switching mode.

7.4.1 Caterpillar with motor

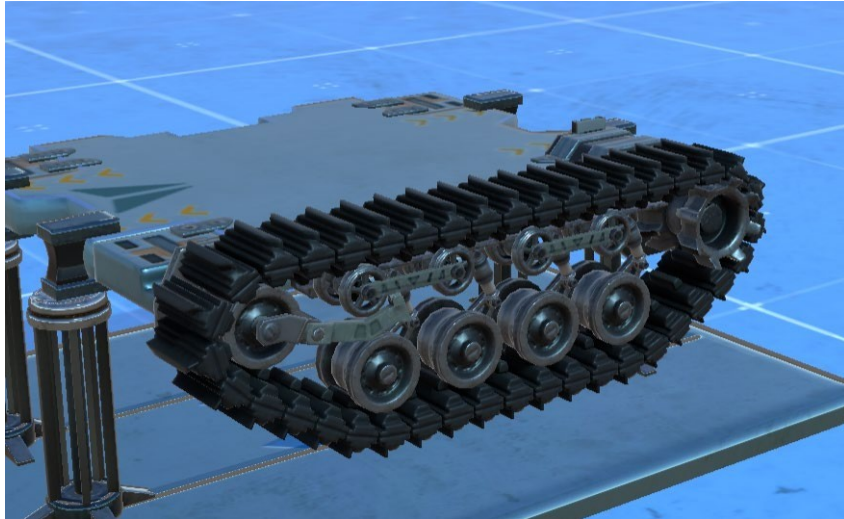


Figure 97 – Caterpillar with motor

A caterpillar is a component that attaches to the chassis and is equipped with a motor attached to the rear wheel relative to the direction of travel (under standard connection). The component is designed to drive the robot chassis. The caterpillar can be right or left depending on the side of installation. The component's motor has a simplified implementation and is combined with a driver in a single housing. The user can select the installation side of the caterpillar and its size.

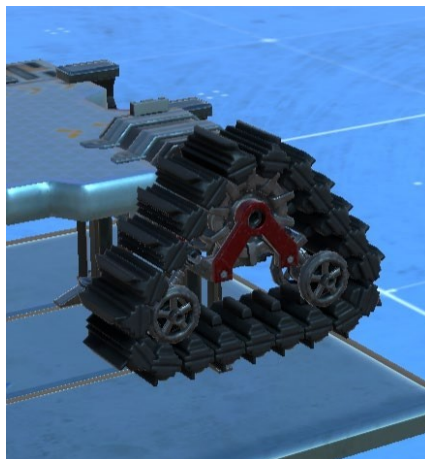


Figure 98 – Caterpillar with motor, small

7.4.2 Wheel with motor

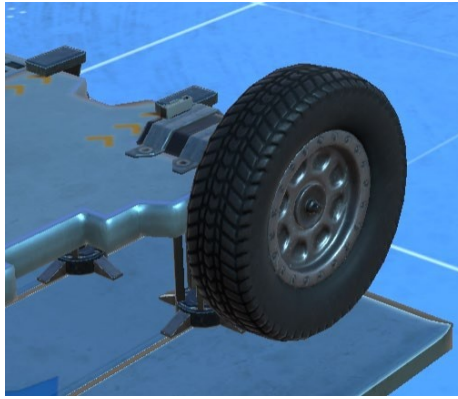


Figure 99 – Wheel with motor

A wheel equipped with a motor allows the chassis to be driven. The wheel can be right or left depending on the side of installation.

The component's motor has a simplified implementation and is combined with a driver in a single housing.

The user can select the installation side of the wheel.

7.4.3 Wheel

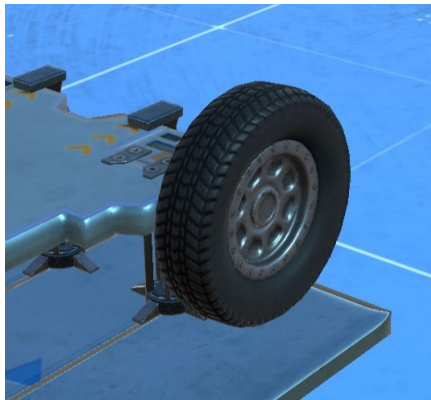


Figure 100 – Wheel

The wheel is a simple mechanism without a motor. It attaches to the chassis and rotates if the chassis moves in one direction or another.

Using wheels, the user can implement front-wheel drive, rear-wheel drive, or all-wheel drive on the robot.

7.4.4 Structural parallelepiped

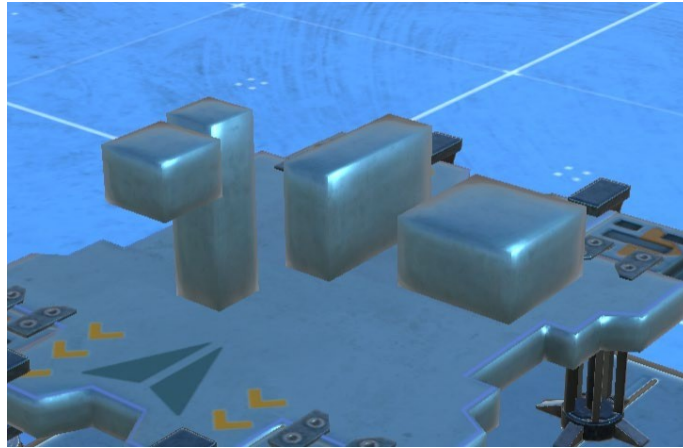


Figure 101 – Structural parallelepiped. Various size and mounting options

A part for mounting on the robot chassis, having the shape of a parallelepiped. It can have various sizes. Other structural elements and some other components stick to its surface. If the parallelepiped is deleted, the components placed on its surface will also be deleted.

The user can set the dimensions of the part within the available ranges.

7.4.5 Structural prism

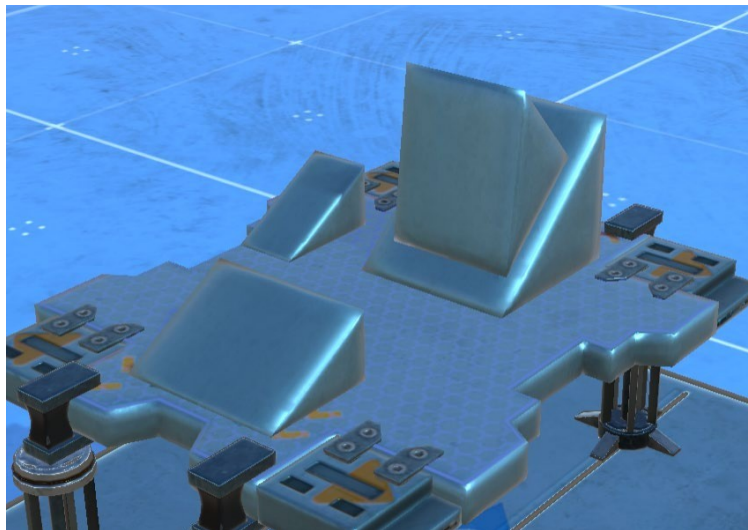


Figure 102 – Structural prism. Various size and mounting options

A part for mounting on the robot chassis, having the shape of a triangular prism with a right angle at the base. It can have various sizes. Other structural elements and some other components stick to its surface. If the prism is deleted, the components placed on its surface will also be deleted.

The user can set the dimensions of the part within the available ranges.

7.4.6 Mobile Manipulator

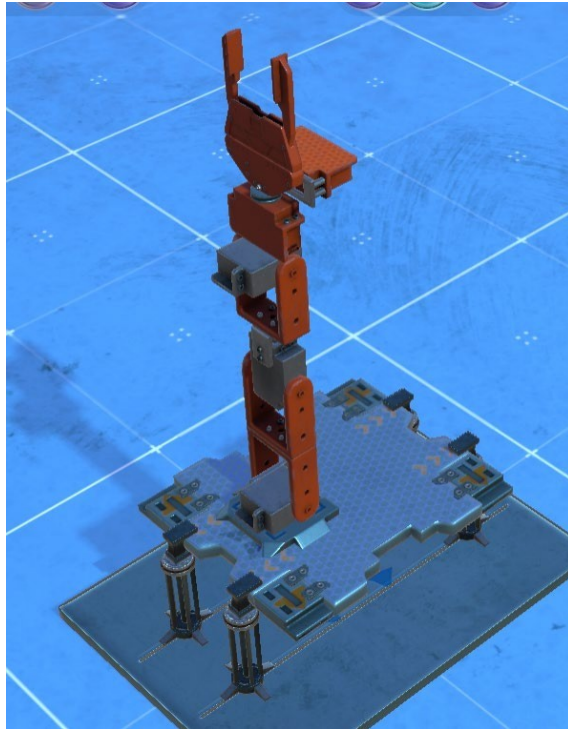


Figure 103 – Mobile Manipulator

A manipulator inferior in size to its counterpart on the Robohand chassis. Its task is to mount on the «Chassis (mobile robot)» and interact with some objects at the polygon. The principles of controlling such a manipulator can be worked out on the Robohand chassis. The component has a built-in set of servos that drive the manipulator.

7.5 Sensor components

Sensor components are used to passively receive data from the three-dimensional polygon and to enable their further processing by the microcontroller. The set of sensor components is available in polygon mode and switching mode.

7.5.1 Temperature and humidity sensor

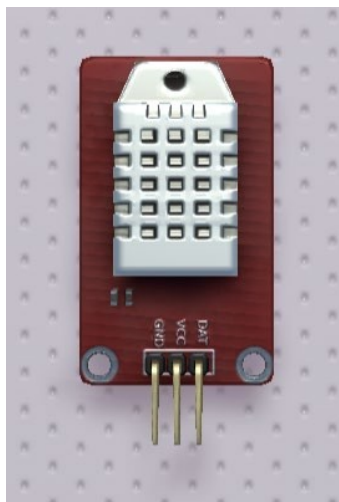


Figure 104 – Temperature and humidity sensor

A digital temperature and humidity sensor is a composite sensor that produces a calibrated digital signal with temperature and humidity readings.

The sensor includes a capacitive humidity measurement component and a resistive temperature measurement component with a negative temperature coefficient (NTC), which are connected to a high-performance ADC (analog-to-digital converter).

7.5.2 Distance sensor

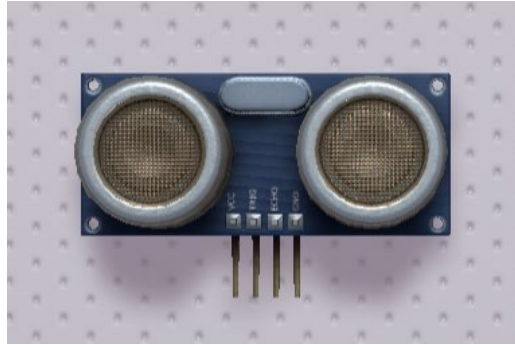


Figure 105 – Distance sensor

The distance sensor generates a narrowly directional signal at a frequency of 40 kHz and catches the reflected signal (echo). By the time of propagation of the sound to the object and back, it is possible to determine the distance to it quite accurately.

The same principle underlies many devices for exploring space: echo sounder, sonar, radar, and even police radar. These devices emit a narrowly directional signal and capture its reflection.

7.5.3 Optical sensor

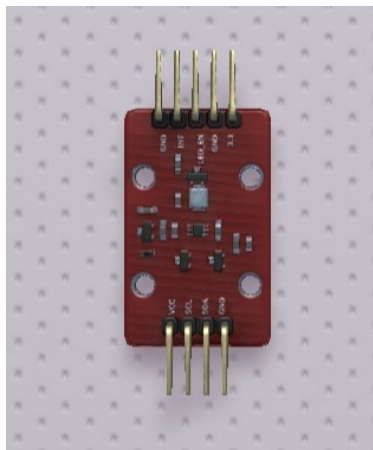


Figure 106 – Optical sensor

The color sensor will help determine the hue of an object in the field of view. It measures RGB components and light levels separately, allowing it to be used to determine the color temperature of lighting or automatically sort items by color.

The user can select the component's operating mode by controlling the built-in white LED manually or, by default, keeping it in the always-on state.

7.5.4 Light sensor



Figure 107 – Light sensor

A photoresistor can change its resistance depending on the level of ambient light. This means that the parameters in the electronic circuit will constantly change. First of all, the voltage incident on the photoresistor. By recording these voltage changes on the analog pins of the microcontroller board, the user can change the logic of the circuit, thereby creating devices that adapt to external conditions.

The user can adjust the potentiometer placed on the component. This will change the sensitivity of the sensor.

7.5.5 Accelerometer

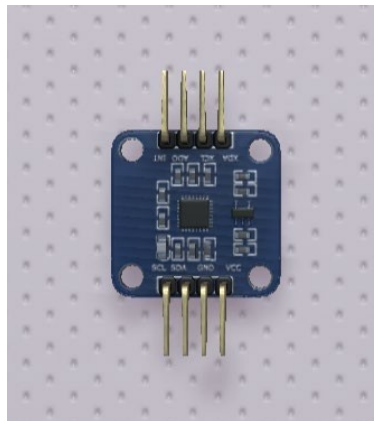


Figure 108 – Accelerometer

An accelerometer is a sensor that allows you to measure the acceleration of a body under the influence of external forces.

7.5.6 Inclination sensor



Figure 109 – Inclination sensor

The inclination sensor detects position and detects deviations in the horizontal plane. It determines whether the active part of the sensor is completely in the horizontal position or tilted.

The user can adjust the potentiometer placed on the component. This will change the sensitivity of the sensor. The user can also choose between vertical and horizontal implementations of the sensor, which increases the convenience of placing the component.

7.5.7 IR receiver



Figure 110 – IR receiver

Infrared (IR) receivers are used in household appliances for remote control of devices from a remote control. They are affordable, simple, and easy to use. The sensor interacts with the IR controller, which can be called through the user interface.

7.6 Electronic components

Electronic components are designed for basic organization of electronic circuits, to which sensor components and mechanical components are connected as peripheral devices. The set of components is available in robot design mode and switching mode.

Below is a description of the electronic components available in the application.

7.6.1 Arduino Uno R3



Figure 111 – Arduino Uno

The Arduino Uno microcontroller board combines the functions of a processor and peripherals on a single chip. In fact, it is a single-chip computer capable of performing relatively simple tasks. The microcontroller is programmed using a version of the C++ language.

Various external peripheral devices can be connected to the microcontroller, which it can control using the code entered by the user.

The context menu of the Arduino Uno component has a unique appearance (Figure 112).



Figure 112 – Context menu of the Arduino Uno component

In the structure of the context menu, the settings sector is replaced by a code input sector. It is selected by default.

On the right side of the application screen, above the electronic components panel, a code input panel appears (Figure 113).

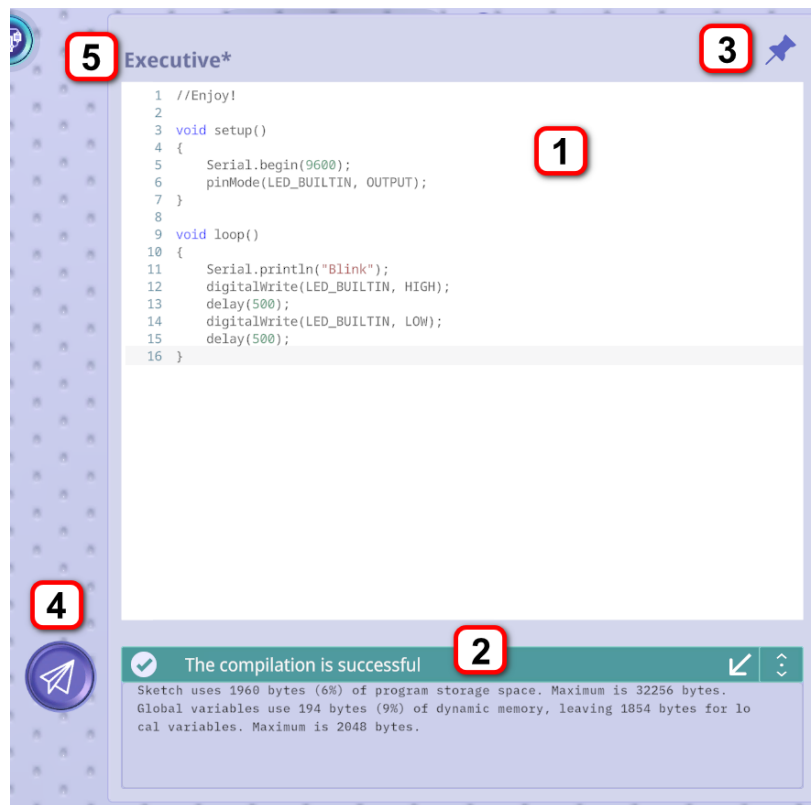


Figure 113 – Code input panel

The code input panel consists of the following elements:

- code input area (1);
- message panel (2);
- panel pin button (3);
- utility buttons (4);
- program change indicator (5).

The **code input area** (1 in figure 113) includes a text field where the program text should be entered, and a line numbering column. The user can collapse methods enclosed in curly braces. To ensure code readability, syntax highlighting configured for the C++ language is introduced.

By default, a basic working program designed to blink an LED connected to pin 13 is placed in the code input area.

The **message panel** (2 in figure 113) is intended to display messages about the results of code compilation or information arriving at the microcontroller's serial port. Consider the structure of the message panel. The appearance is shown in figure 114.

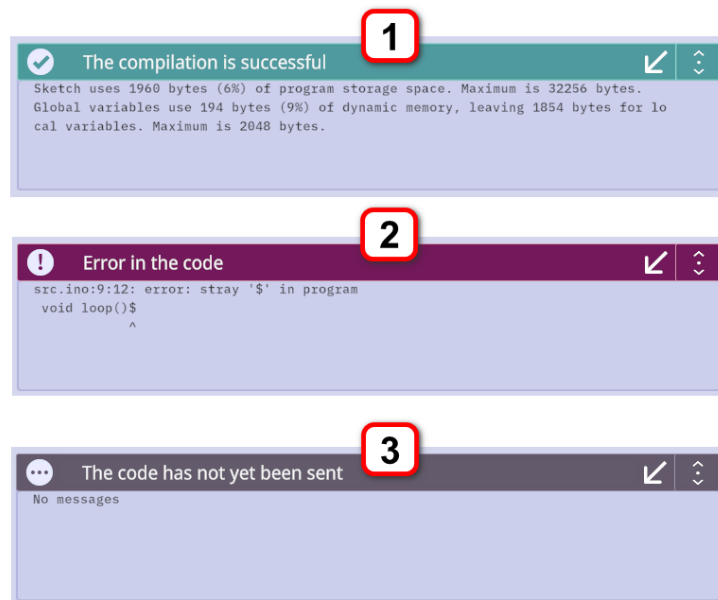


Figure 114 – Structure of the message panel with various states

The message panel can take the following states:

- positive (1), when the program code has been successfully compiled;
- negative (2), when the program code contains errors, making compilation impossible;
- neutral (3), when the program code has not yet been sent for compilation.

These are visualized using the status bar (2). This panel is also a button that can collapse or expand the message panel. If the panel is collapsed, only the status bar is displayed.

The status bar also has an auto-scroll enable button (5). If it is active, as shown in (5), messages arriving in the panel will automatically scroll to the newest. The user can use the mouse wheel or drag the panel up to see older messages.

The **panel pin button** (3 in figure 113) allows you to pin the code input panel to the screen even when the Arduino Uno component is no longer selected. The user can then move around the workspace and select other components. To unpin the code input panel, click the panel pin button again.

The **code submission button** (4 in figure 113) starts the compilation process of the code entered by the user.

The **program change indicator** (5 in figure 113) is an asterisk symbol (*) placed after the code input panel title. If it is displayed, it means that the current program text contained in the panel differs from that currently loaded into the microcontroller.

7.6.2 Shield

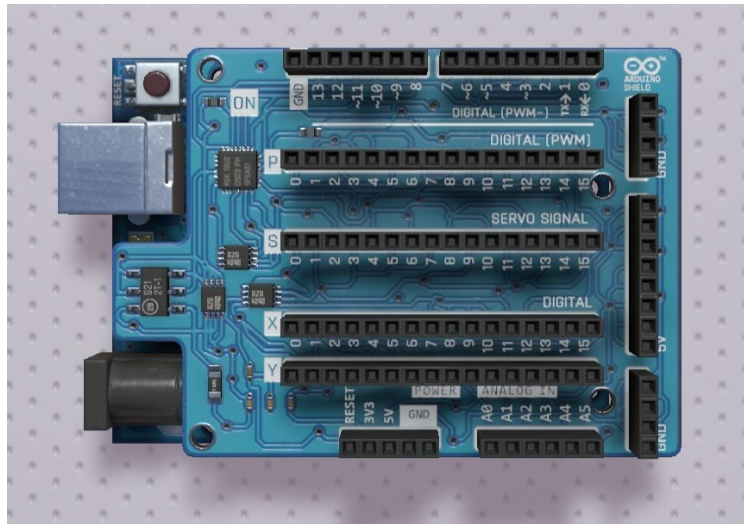


Figure 115 – Shield

An Arduino shield is an additional module designed to expand the capabilities of the existing Arduino Uno R3 platform. It contains additional connectors and a more convenient topology for solving a number of tasks that the user encounters during robot design and switching.

The component can only be created on the Arduino Uno R3. Its interaction is completely similar to the parent component.

7.6.3 Breadboard

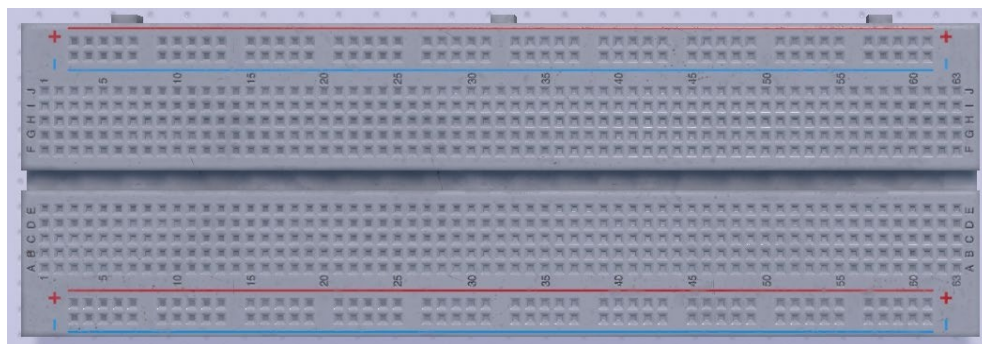


Figure 116 – Breadboard

A solderless breadboard is a tool for prototyping an electronic circuit without soldering.

The user can place components equipped with male pins on the breadboard. Such components include, for example, an LED, a resistor, and a piezodynamic.

Components can be connected via the breadboard using wires.

When moving a component connected to other components by wires onto the breadboard, those connections will be removed.

During connection, the internal buses of the breadboard are highlighted to show the user how electric current will be transmitted when further connections are made. Examples are shown in figure 117.

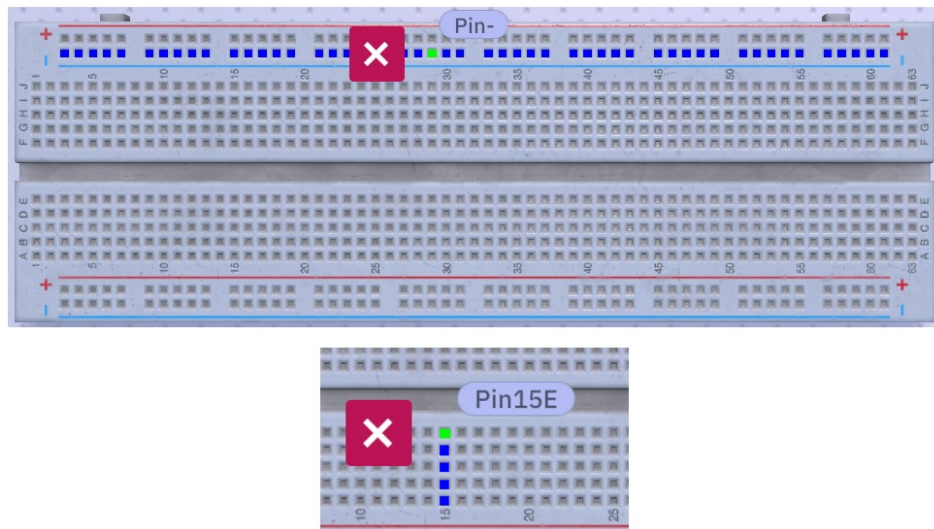


Figure 117 – Breadboard bus highlighting

7.6.4 Bar button



Figure 118 – Bar button

A tact button is a simple mechanism that closes the circuit as long as there is pressure on the pushrod. Buttons with 4 pins represent two pairs of rails that connect when pressed.

The button has an active part in the middle.

7.6.5 Ammeter



Figure 119 – Ammeter

An ammeter is a device for measuring current in Amperes. The device has a display showing the measurement value digitally. The number is rounded to two decimal places, and the unit is set automatically depending on the magnitude of the measurement.

The special position of the contacts reminds the user that the ammeter must be connected in series in the circuit.

7.6.6 Voltmeter

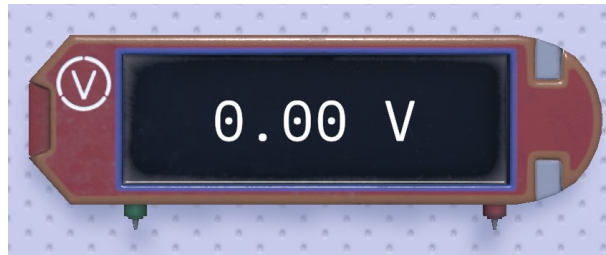


Figure 120 – Voltmeter

A voltmeter is a device for measuring voltage or EMF in electrical circuits. The unit of measurement is the Volt. The device has a display showing the measurement value digitally. The number is rounded to two decimal places, and the unit is set automatically depending on the magnitude of the measurement.

The special position of the contacts reminds the user that the voltmeter must be connected in parallel in the circuit.

7.6.7 Resistor



Figure 121 – Resistor

A resistor is a passive element of an electronic circuit with a specific value of electrical resistance. Unlike active elements, passive ones cannot control the flow of electrons.

The resistor has a special marking indicating its nominal value, i.e., the resistance value. It changes automatically when the resistance value on the component is changed.

7.6.8 Potentiometer



Figure 122 – Potentiometer

A potentiometer is an alternative name for a variable resistor connected as an electrical voltage divider. Potentiometers usually refer to resistors with a movable tap (wiper).

The user can select the potentiometer before starting the simulation and set the current position of the wiper. After the simulation starts, a quick-change slider interface appears above the component. An example is shown in figure 123.

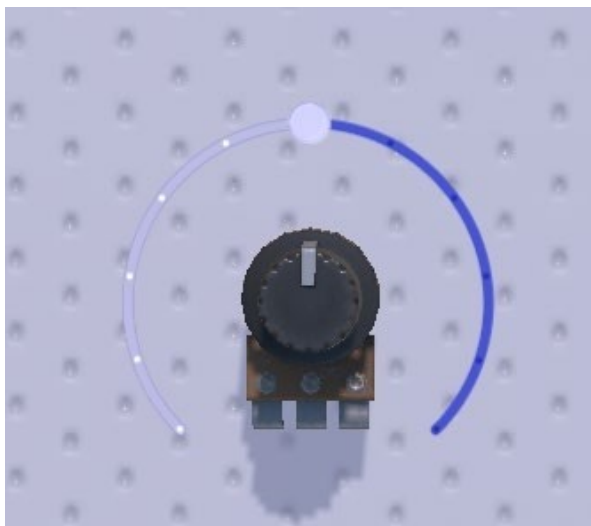


Figure 123 – Potentiometer after starting the simulation

7.6.9 Piezodynamic



Figure 124 – Piezodynamic after starting the simulation

A piezodynamic is an electronic circuit element that converts alternating voltage into membrane vibration, which in turn creates a sound wave.

Since the application is intended for long-term use, including in simulation mode, the sound produced by the piezodynamic is replaced by a visual display shown in figure 124. In the first case,

the piezodynamic is «silent». In the second part of the figure, the piezodynamic is shown in an active state.

7.6.10 Servo



Figure 125 – Servo

A servo drive is a mechanical actuator with automatic state correction via internal negative feedback, in accordance with externally set parameters.

The user can use signals sent from the microcontroller board to control the rotation of the servo rotor.

A structural component can be placed on the servo rotor.

The user can also select the operating mode of the servo. If the «180 degrees» mode is selected, it will rotate to a given angle. If the «360 degrees» mode is selected, the parameter will control the rotation speed of the rotor.

7.6.11 LED

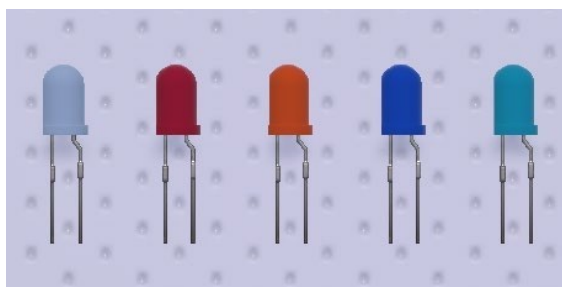


Figure 126 – LEDs of different colors

An LED is a semiconductor device with a p-n junction that produces optical radiation when an electric current passes through it in the forward direction. The light emitted by the LED lies in a narrow spectral range, perceived by the eye as a «color».

The user is provided with various options for selecting the color of the LED. Activating LEDs of different colors requires different input voltages.

7.6.12 RGB LED

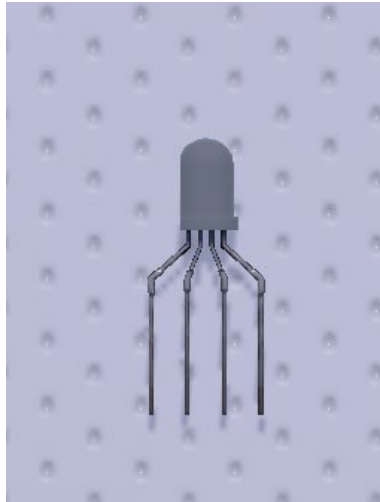


Figure 127 – RGB LED

RGB LEDs are a functional development of monochrome LEDs. An RGB LED is actually three LEDs of different colors (Red, Green, Blue) combined in a single housing. It is possible to simultaneously control the intensity of each color independently and obtain a glow of any shade.

The application implements an RGB LED with a common cathode.

7.6.13 7-segment indicator

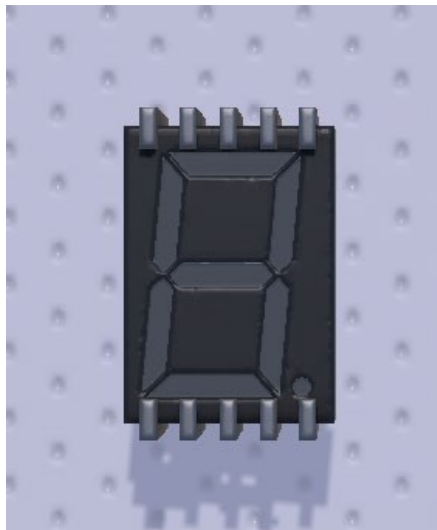


Figure 128 – 7-segment indicator

A 7-segment indicator is a digital information display device. It is the simplest implementation of an indicator that can display Arabic numerals.

The user can choose the color of the LEDs inside the indicator.

7.6.14 LCD display

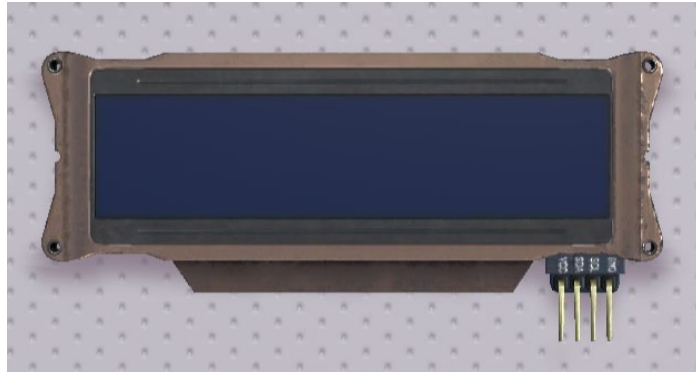


Figure 129 – LCD display

An LCD display is a means of visualizing information controlled by a microcontroller. This implementation of the display has 2 lines of 16 characters each.

The user can select different colors for the display instance, as well as use the display view in the user interface to more conveniently read data from it during a simulation session.

8 Infrastructure failures

The user may encounter a situation where the external server responsible for compiling the microcontroller code is unavailable.

If this happens, next to the simulation button they will see a message similar to the example shown in figure 130.

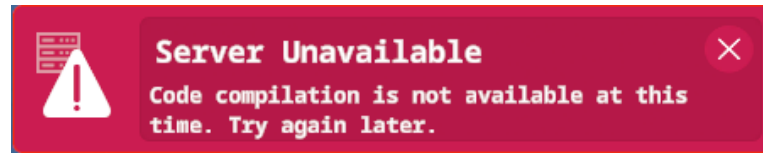


Figure 130 – Example of a server unavailable message

Since the user cannot submit code to the server, the code submission button will be locked. A warning comment will be displayed in the message panel. An example is shown in figure 131.

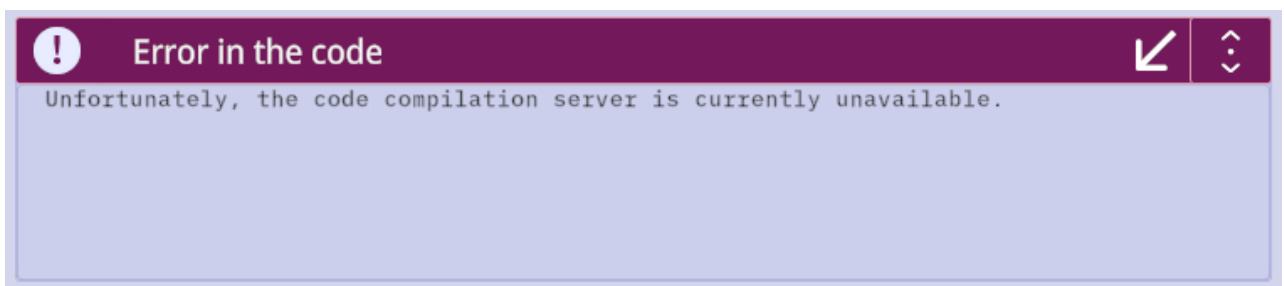


Figure 131 – Message panel with a comment about server unavailability

Even though the user cannot submit code for compilation, some functions of the application remain available. The «5V», «3.3V» and «GND» pins on the Arduino Uno component can be used, allowing the user to create a fully functional electronic circuit.

The application regularly checks the connection with the server. If the connection is restored, the user will be notified of this with a message similar to the example shown in figure 132.



Figure 132 – Example of a message about server connection restoration

If maintenance work is being carried out on the server, code compilation is unavailable. In this case, the application will notify the user with the message shown in figure 133.

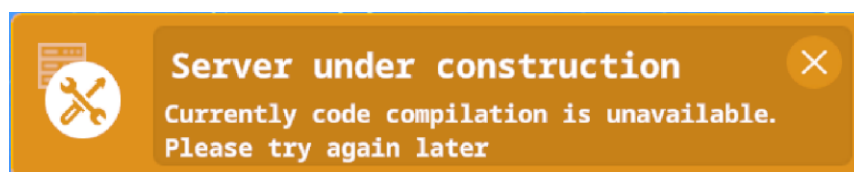


Figure 133 – Example of a message about server maintenance work