

TREE INSPECTION ROBOT COMPETITION

1. OBJECTIVE

The aim of this event is to develop a robot that is capable of ascending, attaching onto, and descending a tree, with bonus options of taking photographs and/or measurements of a specified location on a tree branch.

2. CONTEXT

Urban trees provide us with numerous benefits, such as reducing ambient temperatures, beautifying our living environment, and sequestering carbon from the atmosphere. In order to ensure that these benefits are sustained over time, urban trees in Singapore are regularly inspected by tree care professionals (also known as arborists), to check the health and structural stability of these trees.

Arborists use a variety of diagnostic equipment to detect and assess wood decay within a trunk or branch. Cameras mounted on drones can help arborists to detect surface-level defects on a tree. For assessing sub-surface wood decay in trees, arborists may utilise a resistograph, which is a resistance drill that drives a long and narrow drill bit into a trunk/branch and detects changes in resistance which indicate the presence of decay, or a sonic tomograph, which utilises sound waves to detect the absence or degradation of wood tissue.

While arborists can easily inspect tree parts close to ground level, it takes significantly more effort and resources to inspect a trunk/branch defect at height. This is primarily due to two factors: i) the difficulty of accessing a trunk/branch at height, and; ii) the size and weight of diagnostic equipment, such as the resistograph and the sonic tomograph, which makes it difficult to handle these equipment at height. Currently, in order to inspect a tree part at height, an arborist has to first ascend a tree via a bucket lift, which cannot be deployed at inaccessible sites, or by manually climbing a tree with a rope system, which is a laborious and time-consuming process – all while handling large and heavy diagnostic equipment.

The development of a tree inspection robot, which is able to ascend and attach onto a tree at height, and also has the capacity for mounted diagnostic equipment, would greatly improve an arborist's ability to rapidly inspect a tree branch/trunk at height.

3. BRIEF DESCRIPTION OF COMPETITION

- 3.1 Contestants have to design and build a tree inspection robot that is capable of ascending a tree structure, mounting onto a branch, and then descending the tree structure.
- 3.2 The tree inspection robot should either be remotely operated or fully autonomous, and may also incorporate both autonomous and remote control capabilities, but the robot should only have a single remote control unit.
- 3.3 Points will be awarded based on the ability of the robot to complete the competition task, the load that the robot is able to carry, as well as the practicality and build quality of the robot.
- 3.4 For bonus points, contestants may also take part in one or both bonus options, which involve taking a photograph and measurements of a specified cavity located on the branch that is to be mounted by the robot.

4. TREE SPECIFICATIONS

- 4.1 The tree structure that is to be inspected will be a portion of a live tree. The trunk and branch surfaces will be irregular and covered with bark. The cross-sections of the trunk and branches may or may not be symmetrical.
- 4.2 The tree structure that is to be inspected will have two orders of forking, i.e. at a certain height from ground level, the tree trunk will fork into at least 2 primary branches, and at least one of these primary branches will fork into at least 2 secondary branches.
- 4.3 The secondary branch that is to be mounted by the robot will be marked out with a red 'O'. The red 'O' will measure 5cm in diameter, and may be marked out on any location (i.e. upperside, underside, or flanks) of the secondary branch.
- 4.4 The red 'O' on the secondary branch will be between 4.0-6.0m from ground level.
- 4.5 Refer to Figure 1 for an example of a tree structure that will be used for the competition.

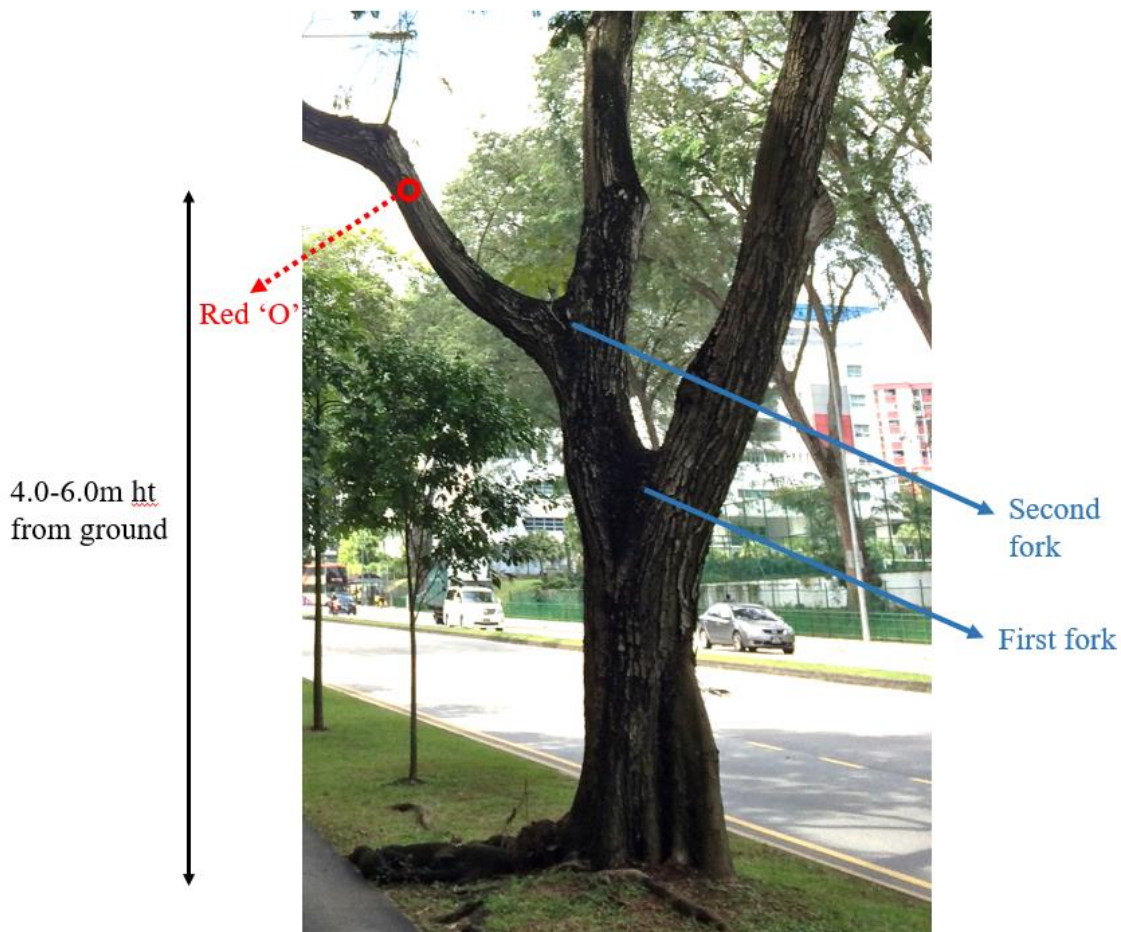


Figure 1. Example of Tree Structure.

5. ROBOT SPECIFICATIONS

- 5.1 The competing robot, together with any accessories, must fit into a box of 50cm (width) x 50cm (length) x 50cm (height).
- 5.2 The weight of the robot and its accessories must not exceed 10 kilograms.

- 5.3 The robot must be capable of carrying a minimum load of 2 kilograms. This load must be a solid cast-iron weight that does not serve any operational function on the robot (as it is a measure of the robot's ability to carry diagnostic equipment in the future). The load can be of any size, and can be attached to the robot in any manner, but must be easily detachable so that its weight can be verified by the judges.
- 5.4 The robot and its accessories can either be self-powered via batteries, or can be tethered to a power source on the ground (i.e. via wires) provided by the contestant. Any batteries should be easily replaceable by the operator of the robot.
- 5.5 The robot's method of ascending the tree is at the discretion of builder. However, the robot's method of ascending the tree should not result in visible damage to the tree structure.
- 5.6 The robot must be powered by a non-polluting energy source. The use of any kind of explosive material, as well as chemical and combustion power methods, is prohibited.
- 5.7 The robot must not discard any part of its chassis during operation, and must not deposit anything permanent onto the tree structure.
- 5.8 The robot must not endanger the judges and the spectators in any way (e.g. by falling from the tree structure during operation).
- 5.9 Any robot found violating these specifications shall be disqualified immediately.

6. COMPETITION RULES AND SCORING

- 6.1 On the competition day, the running sequence of competing robots will be determined by the drawing of lots.
- 6.2 All robots will be caged half an hour before competition starts and will be checked for safety and cloning. Robots found to be of unsafe nature will be disallowed.
- 6.3 At the start, the robot (and all related accessories) must be deployed within a 3m radius from the base of the tree structure. Contestants may mount the robot directly onto the tree trunk, but at least part of the robot must be in contact with the ground at the start of the competition.
- 6.4 The robot is deemed to have completed the competition task when it fulfils all of the following conditions (a), (b) and (c) in sequence:
 - (a) Robot ascends the tree structure;
 - (b) Robot mounts onto the secondary branch marked out by the red 'O';
 - (c) Robot descends the tree structure.
- 6.5 The robot is deemed to have successfully ascended the tree structure when it has released contact with the ground and gained contact the secondary branch.
- 6.6 The robot is deemed to have successfully mounted onto the secondary branch when it has attached to the branch and has adopted a static and stable position for at least 10 seconds, while maintaining contact with the red 'O' for the entire duration.
- 6.7 The robot is deemed to have successfully descended the tree structure when it has detached itself from the secondary branch and, subsequently, gained contact with the ground.

6.8 Each robot will be given a maximum of 30 minutes to complete the task. The competition time starts when the robot releases contact with the ground to ascend the tree structure, and stops when the robot gains contact with the ground after descending from the tree structure.

6.9 For the competition, a total of 50 points shall be awarded in the following manner:

(i) Completion of competition task: 30 points

- 10 points for successfully ascending the tree structure
- 15 points for successfully mounting onto the secondary branch
- 5 points for successfully descending the tree structure

(ii) Load: 5 points

- 2 points for minimum load (i.e. 2 kilograms)
- 3 points for >2 kilograms, but ≤ 2.5 kilograms
- 4 points for >2.5 kilograms, but ≤ 3 kilograms
- 5 points for >3 kilograms

(iii) Practicality: 10 points

(iv) Build Quality: 5 points

6.10 Only two contestants are allowed in the competition arena for each team. In the case of a remotely operated robot, only one of the two contestants is allowed to use the remote control.

6.11 Any objections or appeals on discrepancies on points awarded for the completion of the competition task must be raised within 5 minutes after the team completes its competition attempt and its points displayed on the official results board. Objections/appeals should be submitted in the official appeals form available at the Reception Counter to the event chairperson. No further appeals and objections shall be entertained after the given window.

7. CLONING

7.1 In accordance with the spirit of the competition, clones among the winning entries will only be awarded one prize. Clones will be identified during the "caging" procedure.

7.2 Clones are robots with substantially identical physical appearance and working principles. This rule will be applied strictly especially for multiple entries from the same institution.

7.3 When in doubt, the decision of the Judges will be final. No arguments will be allowed on cloning issues once competition starts and such arguments may disqualify the team.

8. EXHIBITION

8.1 All entries will be allocated exhibition space where the robots will remain throughout the day. Contestants are to man the exhibits at all times and should be available to answer questions from judges and members of the public.

8.2 Prize winners will only be announced at the end of the day of the competition.

8.3 The judges' decision is final and binding to all.

BONUS OPTION 1 (10 POINTS): BRANCH CAVITY PHOTOGRAPHY**1. SPECIFICATIONS**

- 1.1 The robot should have a camera that is capable of taking a photograph of a specified cavity on the secondary branch, and transmitting it to the operator.
- 1.2 The robot's camera should have at least 4K resolution.
- 1.3 The robot should be able to remotely transmit photographs from its camera to an operator at ground level.
- 1.4 The overall weight of the robot and its accessories, including its camera, must still not exceed 10 kilograms.

2. COMPETITION RULES AND SCORING

- 2.1 The camera is to be mounted on the tree inspection robot when submitted by contestants for the caging procedure. The same rules for safety and cloning apply.
- 2.2 The cavity may be located on any location and in any orientation along the secondary branch that is to be mounted by the robot. The cavity may be of any size.
- 2.3 The robot is deemed to have successfully taken a photograph of the specified cavity on the secondary branch when an in-focus photograph of the cavity (displaying its internal condition) has been transmitted to the operator. The robot is remain attached to the branch (i.e. in a static and stable position) while executing the task.
- 2.4 Bonus points shall be awarded in the following manner:
 - (i) Completion of bonus task: 5 points
 - 5 points for successfully taking a photograph of the specified cavity on the secondary branch, including the transmission of photographs to the operator.
 - (ii) Practicality: 3 points
 - (iii) Build Quality: 2 points
- 2.5 Bonus points will only be awarded if the contestants attain a minimum score of 30 points for the main challenge.
- 2.6 Any objections or appeals on discrepancies on points awarded for the completion of the competition task must be raised within 5 minutes after the team completes its competition attempt and its points displayed on the official results board. Objections/appeals should be submitted in the official appeals form available at the Reception Counter to the event chairperson. No further appeals and objections shall be entertained after the given window.
- 2.7 The judges' decision is final and binding to all.

BONUS OPTION 2 (15 POINTS): BRANCH CAVITY MEASUREMENT**1. SPECIFICATIONS**

- 1.1 The robot should be capable of taking measurements (length, breadth & depth) of a specified cavity on the secondary branch, and transmitting the measurements to the operator.
- 1.2 All measurements should be taken in cm.
- 1.3 The robot should be able to remotely transmit the measurements to an operator at ground level.
- 1.4 The overall weight of the robot and its accessories, including its measuring device/accessories, must still not exceed 10 kilograms.

2. COMPETITION RULES AND SCORING

- 2.1 Any measuring device or accessories are mounted on the tree inspection robot when submitted by contestants for the caging procedure. The same rules for safety and cloning apply.
- 2.2 The cavity may be located on any location and in any orientation along the secondary branch that is to be mounted by the robot. The cavity may be of any size. The measurement points for length, breadth and depth will be marked out beforehand on the edges of the cavity.
- 2.3 The robot is deemed to have successfully taken measurements of the specified cavity on the secondary branch when the measurements have been successfully obtained and transmitted to the operator. The robot is remain attached to the branch (i.e. in a static and stable position) while executing the task.
- 2.4 Bonus points shall be awarded in the following manner:
 - (i) Completion of bonus task: 10 points
 - 7 points for successfully measuring the length, breadth, and depth (in cm) of the specified cavity on the secondary branch, including the transmission of measurements to the operator.
 - 3 points for the accuracy of the length, breadth and depth measurements (i.e. 1 point for each measurement, to be within $\pm 2\text{cm}$ of actual measurement).
 - (ii) Practicality: 3 points
 - (iii) Build Quality: 2 points
- 2.5 Bonus points will only be awarded if the contestants attain a minimum score of 30 points for the main challenge.
- 2.6 Any objections or appeals on discrepancies on points awarded for the completion of the competition task must be raised within 5 minutes after the team completes its competition attempt and its points displayed on the official results board. Objections/appeals should be submitted in the official appeals form available at the Reception Counter to the event chairperson. No further appeals and objections shall be entertained after the given window.
- 2.7 The judges' decision is final and binding to all.