Background: A Need to Save Lives
The New Zealand forestry industry is associated with a high risk of injury. The greatest injury rates are associated with the logging operation, in particular felling and skid work. Felling injuries comprise between 25% and 30% of logging injuries annually. The greatest risks to workers from felling are being hit by falling trees or other debris. Manual felling is more dangerous and 50-100% more expensive than mechanised felling.

Currently, mechanised felling requires the use of excavators and other heavy machinery. Although safer than manual felling, excavators are expensive and heavy. The use of excavators to fell trees also causes significant damage to the soil reducing its fertility. They are also limited by steep terrain and right under forest regrowth.

Mechanical Design: Started by a Simple Idea
The general two arm configuration for this design was inspired by an idea provided by our sponsor. The team started with this simple vision and was given the challenge of designing, developing and building a scale prototype which could demonstrate and validate ‘tree-to-tree’ movement, a concept not seen before in the forestry industry. Research was conducted into similar industrial and experimental machines and a large volume of concepts for mechanisms were generated. These ideas were evaluated against a set of design requirements and specifications, and a final design was converged on. A modular kit set design was converged on to make assembly easy and to allow the prototype to be portable.

FEA Analysis for Design
ANSYS and Solidworks were used to perform extensive Finite Element Analysis (FEA) on the arm structure to help gain a better understanding of the forces required to actuate the prototype. Electric actuators for the arms, wrist and grippers were all sized appropriately using actuation force analysis results. FEA simulations were also used to identify high stress areas of the design so that appropriate material selections could be made to maximise strength while minimising weight and cost. Eccentric loading was also simulated to determine the structure’s torsional rigidity in extreme working positions.

Outcomes and Overall Performance
The prototype has been designed, built and assembled by the team at the University. The total weight of the device is approximately 50kg. Two test set-ups were also designed and built by the team: the first being a pole mounted test rig and the second a simulated scale forest environment.

The following tests were conducted to evaluate the prototype’s performance:

- Static test: The device demonstrated its ability to support its own weight. A small amount of play in the actuator connections and some backlash in the wrist gears was observed.
- Strength testing of the linear actuators: All of the 11 actuators were able to demonstrate that they had sufficient strength to lift the arms and actuate the grippers.
- Testing of the wrist, gripper and roller mechanisms: The grippers were strong enough to support the device during operation. The rollers were able to demonstrate some movement around the tree but this movement was not as steady as the team had hoped. Future improvements could be made to this mechanism. Tree-to-tree traversal validation: The device was successfully able to demonstrate and validate the tree to tree movement concept by moving between 3 trees in a simulated forestry environment.

Future Work
The overall prototype has been built to a one quarter scale of what would be required for real industry use on timber harvestable trees. In its current state, the prototype is able to demonstrate tree-to-tree movement and has validated it as a means of traversing through a forest.

Future works which could be conducted to improve the prototype include:
- Development of software which will plan the path for the tree climbing robot in a forest.
- Integration with cameras and remote control for tele-operation.
- Development of attachments that will be mounted on the tree climbing robot traversing platform (e.g. felling tools, measuring devices etc.).
- Design and build a full scale prototype to test in a real forest.

The innovation: Scion have a concept to fell trees mechanically using a remotely operated robot to traverse between trees in the forest. The team’s challenge was to design and build a remotely operated robot that can traverse between trees. This concept will provide a safe method for tree felling that will preserve the forest soil.

The electronic design and control:
The robot uses three microcontrollers to independently control the eleven motors which actuate the device. The entire system is wirelessly controlled via a laptop using Bluetooth. Rotary encoders in the robot joints provide angular position feedback to the main microcontroller. Kinematics have been developed to provide straight line motion control of the free gripper.

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