

Build a paper robot

A half-day design-and-build project for 25-50 people

Introduction

This project requires a large team of participants to build a 2.4-metre tall humanoid robot from paper and string, capable of moving in order to perform a number of specific tasks. The aims of this project are:

- To explore the relationship between observing, drawing and making;
- To explore simple mechanisms for moving structures; and
- To teach students about the coordination between different parts of a design team.

The many anatomical sketches that Leonardo da Vinci produced in his codices were the inspiration for this project. Da Vinci used sketching as a way to study and explore the real world. In much the same way, this project starts by asking participants to make sketches of parts of their own body in order to understand how they can design and build a given component of the robot. The human body uses a combination of simple joints to achieve a very large number of complex movements. Studying the human body is an excellent way of learning about how mechanisms work. The parts of the human body all fit together and work in harmony with one-another: coordination between the various parts of the design team is therefore essential to ensure that their robot also works in harmony.

This downloadable document contains participant and facilitator briefing notes, which can be printed off separately. The facilitator briefing notes give details of the material and space requirements for running this project.

Participant briefing notes

Brief

Your brief is to design and build a 2.4-metre tall robot based on the structure of the human skeleton. Each of the major bones and joints of the human body should be identifiable in the robot's structure. The robot's joints must be capable of making the same movements as the major joints in a human. The robot should hang comfortably from the ceiling and be attached as a minimum at the pelvis, and, if necessary, at the robot's shoulder-level. The full anatomical requirements are given in the specification below.

The only construction materials that you are allowed to use for this project are the A4 paper, sticky tape, metal rings and string provided.

Once you have built your robot you will be required to make it move, using string to simulate the system of tendons in the body (the full kinetic requirements are also given in the specification). The robot's movement may only be controlled by pulling on the pieces of string. Unlike a puppet (where the strings go straight up to the puppeteer from the arms and the legs), the strings controlling the robot should run where the muscles and tendons in a human normally lie: beside the bones and across the joints. Keep the tendons in place by passing them through rings attached to the skeleton. To avoid unnecessary tangles, each bit of the body (for example the hand or the leg) may be controlled by its own local nerve centre.

Specification

Anatomical requirements

The robot must be 2.4m tall and requires the following body parts:

- Two legs, each with a foot;
- Two arms, each with a hand; and
- A head, with a moveable jaw.

The robot requires the following joints:

- Each arm should have a shoulder, an elbow and a wrist;
- Each hand should have four fingers and a thumb;
- Each leg should have a hip, a knee and an ankle;
- The head should be able to turn from side to side, with a jaw that can be moved up and down;
- There should be a spine-chest-shoulder-pelvis system to which the legs, arms and head should be attached. The spine will require some articulation in order to be able to achieve all of the movements required below.

Kinetic requirements

The robot must be able to:

- Move each arm;
- Pick up an object in its hand;
- Bring the object up to its mouth, turn its head and bite it;
- Move its legs as if it is walking like a human (bending at the hip and knee and raising and lowering the foot);
- Touch its toes and then stand straight again; and
- Turn to one side and wave.

Team organisation

Organise yourselves into groups of 4–5, each assigned to look after a different part of the body. It is suggested that you assign the groups to the following body parts: head – one group; arms – two groups; hands – two groups; chest/spine/pelvis – two groups; legs – two groups; and feet – two groups.

Learning how to co-ordinate between the different parts of a design team is one of the aims of this project. Each group should nominate one member to be part of a co-ordination group that will make sure that each body part is able to attach to these others properly. If you find yourselves over-stretched, you can negotiate with the other groups to borrow their students, to suit your workload. Try to plan how many people you need in advance rather than having to fight over resources at the last minute.

Starting points

Remember that one of the aims of this project is exploring the relationship between observing, drawing and making. The starting point should be observing your own body. Sketch the bit of the body that corresponds to the part of the robot that you are designing. Use the sketch to explain how the mechanical systems in that part of the body work.

Your group will need to decide on the size of the ‘bones’, the number of joints in your particular part, the range and type of movement of each joint and where to attach and route the strings.