General overview of the kinetic elements built by Nervous Squirrel Ltd.

The sculptures have been built with safety, reliability and ease of maintenance in mind. The sculptures are self-calibrating where necessary, running checks before and during movement routines where possible, to make sure that everything is functioning as it should.

Bearings have been used for any pivoting or rotating mechanisms to ensure a long working life. The bearings selected are all larger than strictly necessary, to make sure the mechanisms are long lasting and reliable. All motors use planetary, spur gear or worm gearboxes to provide plenty of torque. Flexible shaft couplers have been used where necessary, to prevent lateral wear of bearings.

Off the shelf / easily obtainable parts have been used wherever possible. All motors, gearboxes and bearings have standard footprints to facilitate easy replacement. Parts that may wear over time have been designed to be unbolted, although fixings susceptible to vibration have been secured using nyloc nuts, lock washers or threadlock.

No grub screws have been used on any of the bearings - circlips or roll pins have been used for increased reliability.

Sensors for calibration are non-mechanical where possible, i.e. inductive, optical or current sensing, to eliminate wear.

Control

A PCB was designed for this project, as an interface between the Teensy 4.1 microcontroller and the various items that it controls. The generic board has been implemented differently for each kinetic item, depending on what needs to be controlled or monitored.

An ancillary BC847 transistor buffer board was also designed for where 5V level signals need to be controlled. Note that this differs greatly from a standard BSS138 "level shifter" board, in that the custom board can deliver higher currents necessary to interface with the stepper motor driver optocouplers, and can also produce cleaner fast rising edges when operating at high frequencies. The transistors used on this board are essentially a SOT-23 package version of the NPN BC547.

The documents for the specific kinetic items have been written assuming the code / functionality is the same as when each item was delivered. Note that the code may have since been updated by others.

The metal enclosures are all from RS Components, typical example: order code 775-5814

General notes on maintenance

It must be understood that any mechanical part, including motors, gearboxes, belt drives, power supply fans, bearings etc. are consumable parts, and are expected to wear out over time.

Running the kinetic sculptures more frequently will wear them out more quickly. Less frequent activations = longer operational life.

It is highly recommended that records are kept of any parts that are replaced, including details of the part that was replaced and details of the new part (supplier, part number, who changed it, date etc).

Make sure that each sculpture is checked at least daily for normal operation. It is recommended that allocated technicians have a routine involving a visual check of the pulley frames, hanging baskets, tug of war, hairdryer, windmills and eyeball. Each technician must be familiar with the ordinary movements of each kinetic element, so that any irregularities can be noted immediately. Any unusual movements, sounds, or other evidence of non-standard behaviour must be followed by powering off the sculpture and investigating. Things will go wrong over time! It's better to catch any faults early.

It is recommended that responsible technicians can detect any issues a day before they happen just by sense of smell.

Make sure the sculptures are turned off at night, so that they're not being worn out needlessly. Don't run the sculptures when there's no-one there to see them.

Any power supply can be replaced like for like as long as voltage and current ratings are matched. It is expected that power supplies will fail over time, either from repeated power cycling or fans wearing out eventually.

Some of the control boxes contain an extra fan attached to the outer casing to prevent excessive build up of heat. If the fan isn't functioning, replace with an 80mm equivalent, either 12V or 24V as labelled.

Note that the stepper motor drivers used on this project have a switch that sets whether the inputs respond to 5V or 24V signals. The switch is usually set to 24V when it arrives from the factory, and needs to be set to 5V to work with this system. If you're reading this after 147 hours of troubleshooting, take some time out for a cup of tea.

The documents for the individual kinetic items have further details on specific maintenance requirements.

General notes on operation

Each of the kinetic items was supplied so that when power is applied the sculpture calibrates if necessary and then enters its day to day routine. This has now likely been changed to include network connectivity / show control, implemented by others. "Operation" generally just involves applying power.

Each control box PCB has a 16 position rotary selector switch that allows various test and calibration modes to be set, as noted in the documentation for individual kinetic items.