Eyeball overview

The eyeball consists of acrylic hemispherical dome sections mounted on a steel frame. An internal gimbal provides support for the eyeball, and an external gantry holds the eyelids in place. The eyelid gantry can be unbolted and separated from the remainder of the steel frame if required.

Movement is provided by 7 stepper motors in total, each fitted with a 10:1 ratio planetary gearbox for increased torque.

The X axis uses a 12Nm NEMA34 closed loop stepper motor. The Y axis and eyelids use *pairs* of 4Nm NEMA24 motors. The pairs of motors use two stepper drivers with control inputs wired in parallel, but with the direction DIP switches set in opposite directions. Don't fiddle with the DIP settings.

The X axis position is detected using a 12 bit absolute encoder. The Y axis and eyelid limits are detected using inductive proximity sensors.

On powering up, the eyeball goes through a homing routine, entering an error state if anything is amiss. Once the home positions have been found, the closed loop stepper drivers monitor the movement of the motors from then on, meaning that if supplied pulses don't correspond with the expected motor movement the driver will shut off the motor and enter an error state (red flashing LED on the driver).

The homing of the Y axis and eyelids involve a fast approach, followed by backing off and then a slower approach for increased accuracy. This accuracy is required so that the eyelids can blink without colliding, although there are also physical stops to prevent this.

On powering off, a pair of 4PDT relays deliberately short the motor coils on one of the Y axis motors and one of the upper eyelid motors. This acts as an electronic brake, so that the acrylic parts descend slowly rather than crashing down violently under their own weight. Don't unplug the motor power with the system powered up, as this will override the brake setup and damage the acrylic.

The X axis has a damping system to make the eyeball movement smooth. This consists of a stainless steel semicircular bracket connected to the rear of the gimbal, sandwiched between two pads of sheep's wool. The pad pressure is adjustable.

After the homing routine is complete, the eye currently enters a behavioural mode where it glances around at random, returning to a central position fairly regularly. This mode also involves random blinks, and a 15% chance of an occasional double blink.

Maintenance

Periodically inspect in and around the eyeball for loose fixings, misaligned parts, any powder or liquid residue that implies excessive friction or parts rubbing.

Check that the power and data cables to the eyeball gimbal are free to move and haven't frayed.

Check that the eyelids aren't clashing, and that the eyeball is moving smoothly without excessive jerkiness. Adjust the anti-wobble friction pad pressure if necessary.

Generally check the eye's movement for any change from what is expected.

These checks inside the eyeball initially to be carried out daily, later weekly when the eye has been running successfully for at least 2 or 3 weeks.

Visual checks of eye movement from a viewpoint below the balcony to be carried out daily.

After 5 years, check the bearings. Add oil via the grease nipples if necessary.

Rotary switch modes

0: Automatically calibrate and then run normal routine. Glance around at random, with pauses, occasionally blink or double blink.

The following modes need a button press to initiate (tactile push button no. 1 on the PCB):

1: Full homing sequence for testing
2: Movement of eye to limits of travel
3: Circular eye roll to limits of travel
4: Blink test
5: Random glance routine, faster, for testing
6: As 5, but with blinking also
7-15: Unused

Things to watch out for

Don't unplug the motor power cables with the eye powered up - the eyeball and eyelid will crash down violently if the braking system is disconnected when in use.

When programming new routines, make sure the homing routine is always carried out first, and be absolutely sure of the maximum amount of pulses that the eye and eyelids can move in any direction. Programmed movement of the eye beyond its limits will crash the fragile acrylic into the steel frame.

Note that a rare edge case could occur if 230V power is cut but then very quickly restored. In normal operation when the power is cut, the acrylic descends slowly. If power is cut and re-applied quickly, there is a short time where in theory the relays are online (meaning no electrical brakes), but the stepper driver hasn't woken up and "grabbed hold of" the acrylic components using the motor holding torque. This means the acrylic might drop during this startup time. In normal operation it's unlikely the power would ever be cut and re-applied for any reason.

Troubleshooting

The most likely error state that the eye will end up in will be no movement, likely caused by a homing failure.

There are watchdog pulse counting timeouts on the various movements that the eye carries out on startup. If a motor or sensor fails, the homing sequence won't complete and there will be no further movement.

Check serial output for diagnostic clues.

Notable components

NEMA34 stepper motor kit (including driver and power supply), Stepper Online part number 1-CLTS120-V41
NEMA34 10:1 planetary gearbox Stepper Online part number EG34-G10
NEMA24 stepper motor kit, Stepper Online part number 4-CLTS40-V41
NEMA24 10:1 planetary gearbox Stepper Online part number EG24-G10
Generic inductive proximity sensor, any manufacturer, model LJ12A3-4-Z/BX
12 bit absolute encoder, 6mm shaft, Ali Express, model BRT38-S0M
4PDT relays, RS Components part number 613-3780
Acrylic fabricated by projectplastics.co.uk
Motor power and data extension cables had to be custom made
Wool from a sheep in Wales

Colours

Eyelids: 1K RAL 4010
Steelwork: 1K RAL 9010
Iris: Vauxhall 21D Sardinia blue pearl with black details
Acrylic: opal white