Supplementary Information for:

An open platform for high-resolution light-based control of microscopic collectives

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Supplementary Note 1: Arena for *Volvox* experiments

To allow the free movement of *Volvox* colonies, a sample area (see image below) was constructed. A square chip of outer dimensions 25 mm x 25 mm with a 7.75 mm x 7.75 mm square cut from the middle was 3D printed in PLA and attached to a standard glass microscope slide using superglue adhesive. This square well has depth of 1.5 mm, allowing *Volvox* colonies of 350–500 µm in diameter to move freely in the *x-y* plane, with some limited movement in the *z* plane.

a

b

c

d
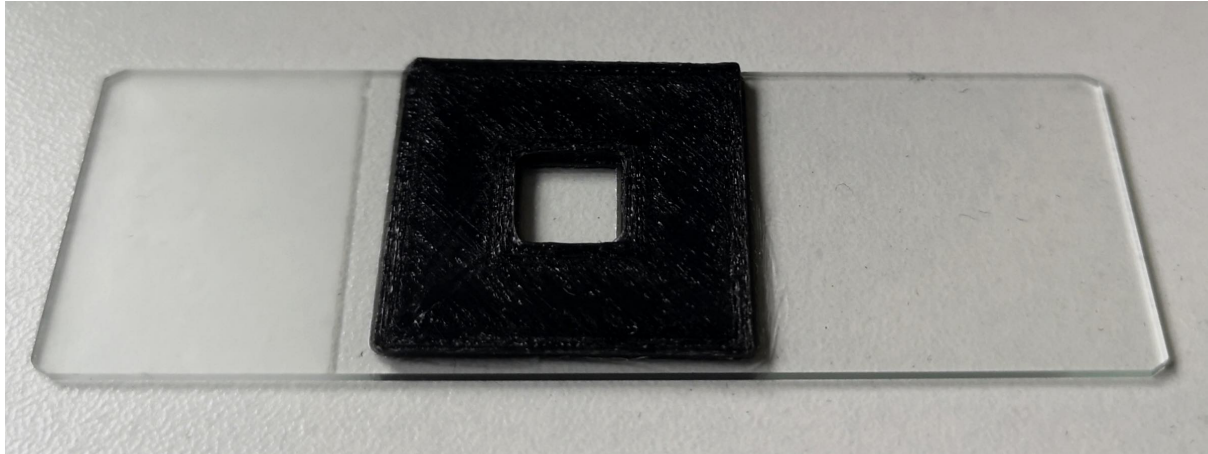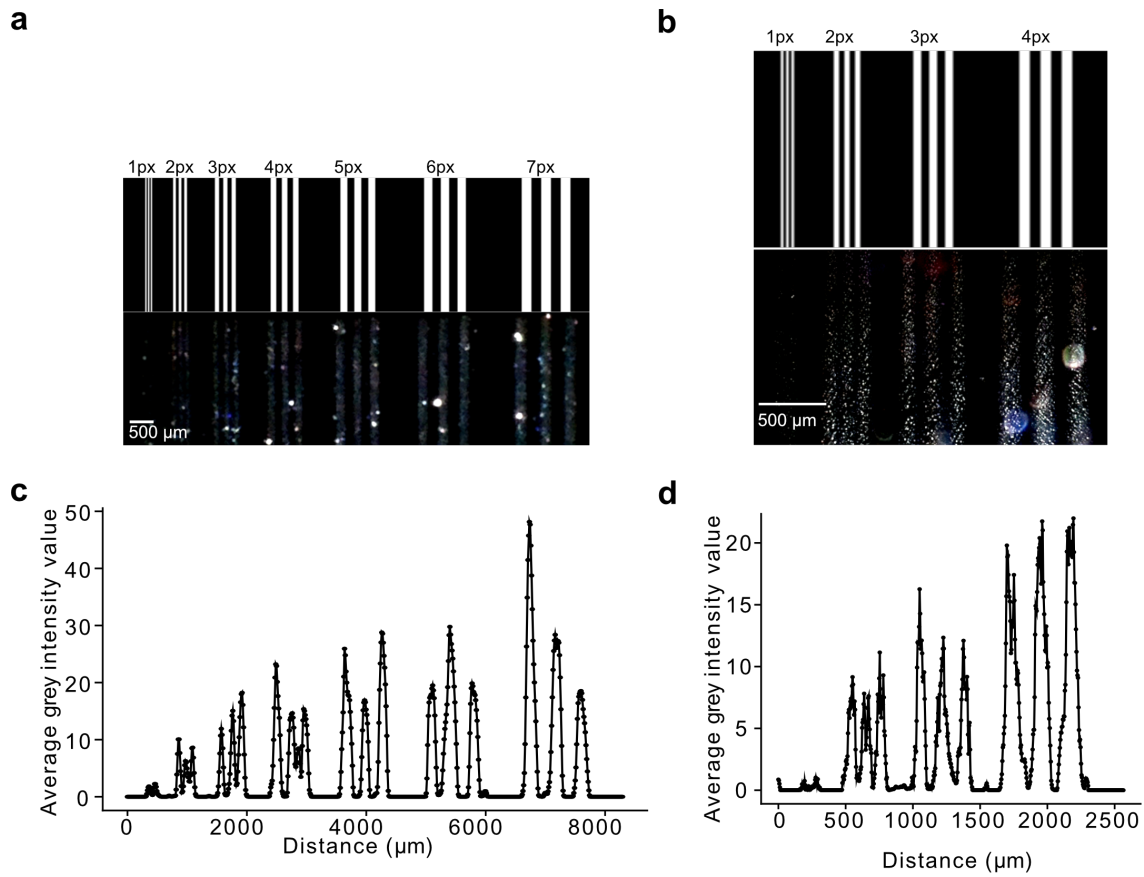
Supplementary Figure 1: Characterisation of projection and imaging modules. (**a**) Projection image of line triplets of increasing width up to 7 pixels for 9X magnification (upper) and corresponding camera image (lower). (**b**) Projection image of line triplets of increasing width up to 4 pixels for 90X magnification (upper) and corresponding camera image (lower). (**c**) Intensity plot across test image for 9X magnification, measured as the average grey-scale value for each pixel column in the image. (**d**) Intensity plot across test image for 90X magnification, measured as the average grey-scale value for each pixel column in the image.
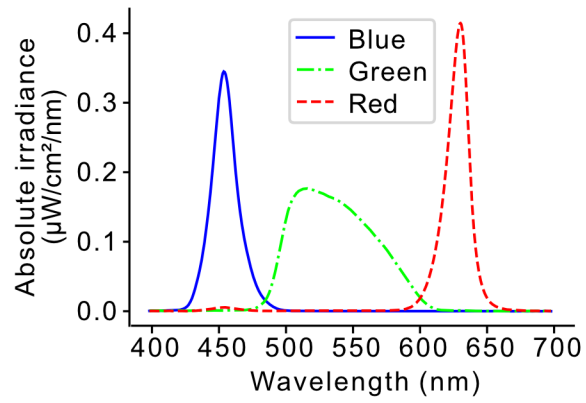
Supplementary Figure 2: Light spectra of projection module. Spectra of light emission from the projection module showing clear separation of the red, green and blue LEDs.

Supplementary Figure 3: Latency of closed-loop control applications. Latency of closed-loop control as a function of camera resolution. Red line shows a second order polynomial fit of $y = 6.8x^2 + 32.6x + 231$.

Supplementary Table 1: Breakdown of DOME component costs.

Optical	Cost (£)[a]
Projector (DLP Lightcrafter Display 2000 EV, Texas Instruments)	109
Condenser lens (50mm Diameter PCX , Edmund Optics)	37
Tube lens (9X Eyepiece Cell Assembly, Edmund Optics)	61
10X objective (Semi-Plan Standard Objective, Edmund Optics)	122
Glass diffuser (DG10-1500, Thor Labs)	15
Neutral density filter (NE10B-A, Thor Labs)	47
Longpass filter (FEL0500, Thor Labs)	60
Electrical	
Raspberry Pi (Raspberry Pi 4 Model 4GB, The Pi Hut)	54
Raspberry Pi (Raspberry Pi Zero W, The Pi Hut)	9
Camera (Raspberry Pi Camera V2, The Pi Hut)	24
2 × SD card (SanDisk Ultra 16GB microSDHC, Amazon)	14
Interface PCB (Pi Zero W DLP2000EVM adaptor board, Tindie)	3
Power supply (UK Raspberry Pi 4 Power Supply The Pi Hut)	8
Power supply (Raspberry Pi 3 Universal Power Supply)	8
Mechanical	
PLA filament (Black Premium PLA 1.75mm, FilaPrint)	28
Linear rail set (Glvanc 3D Printer Guide Rail Sets, Amazon)	21
x-y stage (Zetiling Microscope Moveable Stage, Amazon)	15
Linear Motion Ball Bearing (LM8LUU, Amazon)	7
Lighting and fastening sundries	41
Total cost	**685**

a. All prices given to the nearest pound (£) and inclusive of 20% VAT.

Supplementary Movie Captions

Supplementary Movie 1: Communication. Light-based communication between motile *Volvox* colonies with a 20 px communication range. Non-messaging *Volvox* appear in red due to illumination by a uniform red background light, while messaging *Volvox* are illuminated in cyan. Propagation of the message can be seen throughout the population over time.

Supplementary Movie 2: Programmable messaging. Programmable messaging between *Volvox* colonies. A blue and green seed are initialized and propagate through the population until a majority in the mixed state colored in cyan is reached.

Supplementary Movie 3: Stigmergy. Light-based stigmergy with *Volvox* colonies depositing light trails in cyan. Agents can be seen to change velocity upon encountering a light trail.

Supplementary Movie 4: Motion control. Selective light-based control of *Volvox* movement. Half the *Volvox* population (randomly selected) are illuminated with blue light for 2 frames every 10 frames, causing a slowing of their movement.