Supporting Information

Supplementary Note 1: Energy in Rotational Springs while Perched

The energy stored in the rotational springs while perched is a function of the diameter of the rod or bar being perched on. This is because on a larger diameter of perch (D in **Figure S1**), the fingers (and therefore rotational springs) are held stretched in a wider position (Figure 10(a-c)). We develop a simple model to predict this. Our model simplifies the palm and fingers of the claw to bars connected by hinges. The angles between the hinges match the states of the rotational springs. Contact between the perching structure and the claw is assumed to occur at the middle of the phalanges. Thus the middle of the palm and middle of each phalange are three points that form a circle which corresponds to the cross section of the perching structure. For our analysis we calculated the corresponding D as well as the stored energy for every combination of angles from 90 to 179 degrees(blue circles in Figure S1).

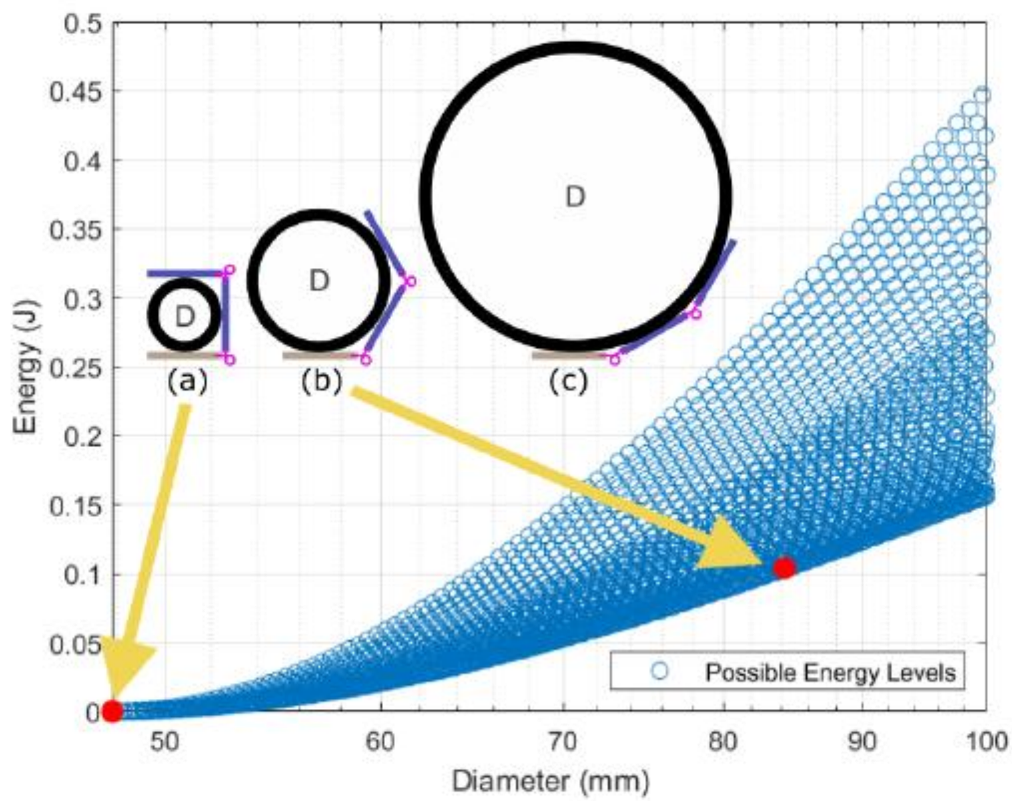

Figure S1: Plot showing how increasing the diameter, D, of the perch (black circles on drawing) changes the amount of energy stored in the rotational springs (pink). (a) represents the rest state of the springs, which has an energy of 0 (first red dot). (b) is the springs stretched a small amount and the corresponding energy level (second red dot). (c) is the springs stretched a large amount. This corresponds to a diameter larger than 100mm and so is not shown on the plot.

As the perching structure diameter increases, so too does the energy stored in the rotational springs, as they are held in a wider position. Below 48 mm the energy is zero, because below 48 mm, the perching structure is not wide enough to contact all three points and stretch the rotational springs. For some diameters, there are multiple energy levels. This corresponds to different combinations of phalange angles that correspond to the same diameter of perching structure. In these cases, the system would trend towards the lowest energy level for a given diameter. In a real scenario friction in the parts as well as other forces may result in the claw not reaching the lowest energy.

Supplementary Note 2: Estimation of Drop Height Prior to Recovery

To calculate how far the UAV will drop before recovering to level flight, we follow the method from section 6.17 in Anderson [21]. When nose-down, the lift from the UAV is the only force acting parallel to the ground (**Figure S2(b)**). Therefore the rotational resultant force in the radial direction is simply the lift. From Newtons second law the force in the radial direction is (equation 6.117 in [21]),

$$F_r = \frac{mV^2}{R} \tag{5}$$

where m is the mass of the UAV in kg, V is the velocity in m s^{-1}, and R is the turn radius in m. Setting equation 5 equal to lift and solving for R gives,

$$R = \frac{V^2}{gn} \tag{6}$$

where g is the acceleration due to gravity in m s^{-2} and n is the load factor, the ratio between lift and weight. The weight of the aircraft is 8.35 N, but estimating the lift is not as straight forward. In the case of a UAV pulling up to return to level flight, the generated lift could be underpredicted by the static lift coefficient as the fast pitch rate of the vehicle would induce unsteady flow over the wings. A better estimate would be the dynamic lift coefficient. This is more difficult to measure, however, the dynamic lift coefficient of a similar aircraft (the Bixler 2) was measured for a range of rotation speeds [22].

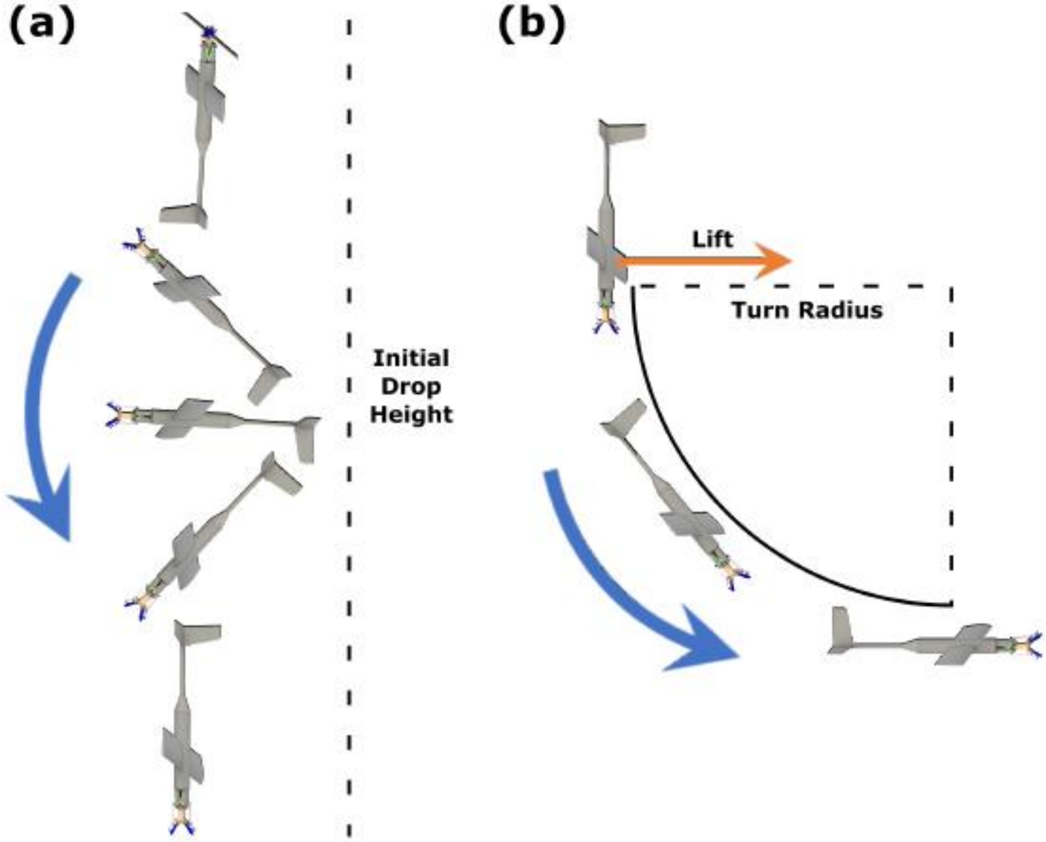

Figure S2: Diagram of the unperch maneuver. (a) Initial drop. During this period the UV drops backwards towards the ground. The vehicle rotates 180 degrees to a nose-down position. This was measured experimentally for the UAV used in this paper and was found to be 5.1 m. (b) Recovery. This segment of the unperch maneuver consists of a pull-up maneuver where the UAV returns to level flight. This portion of the unperch maneuver is estimated using the method outlined in Anderson [21]

The rotation speed of the aircraft just before impact was measured from the motion capture data. At the moment of impact, the vehicle had rotated 172 degrees from the point of release. This was 0.18 s after the vehicle was at 90 degrees, giving an average rotation speed in that time period of 456 degrees s^{-1}. The maximum rotation speed tested by [22] was 80 degrees s^{-1}, so we use a lift coefficient of 2.0 which is approximately the maximum lift coefficient for that rotation rate. The lift can then be calculated using,

$$L = C_L 0.5 \rho V^2 S \tag{7}$$

where C_L is the lift coefficient, ρ is the air density (1.225 kg m^{-3}), and S is the wing area (0.24 m^2 for our UAV). Using the lift coefficient of 2.0 and velocity of 5 m s^{-1} gives a lift of 7.35 N. Thus the load factor n is 0.88, and the estimated turn radius is 2.9 m. Given the 456 degrees s^{-1} rotation speed and the 5 m s^{-1} velocity, after a further 0.02 s and 0.1 m drop, the vehicle would have reached perfectly nose-down.