

RADIO-CONTROLLED CYBORG BEETLES

Micro air vehicles (MAV's)

- vehicles navigable into locations not easily accessible to humans
- man made:
 - limited in size
 - payload
 - distance
 - performance
- insects:
 - unmatched flight performance
 - increasingly understood muscular and nervous systems
 - amenable to internal manipulation during pupation
- efforts to implant microsystems into insects to control their flight

Possibilities of controllable insects

- In biology:
 - studies of insect communication
 - studies of flight energetics
 - studying the foraging behavior of insect predators such as birds
- In engineering:
 - models for insect-mimicing MAV's
 - can be used as MAV's and serve as couriers to locations not easily accessible to humans or terrestrial robots



Radio-controlled cyborg Mecynorhina beetle



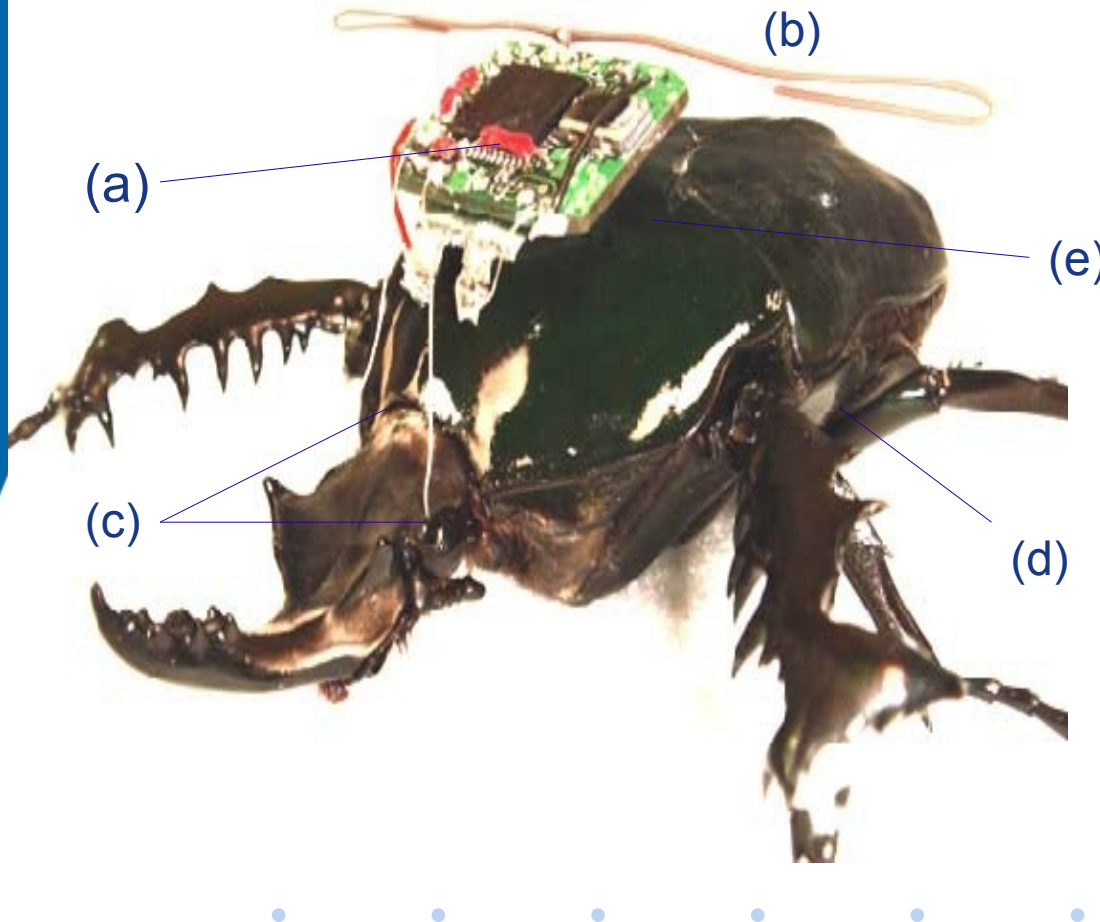
(a)



(b)

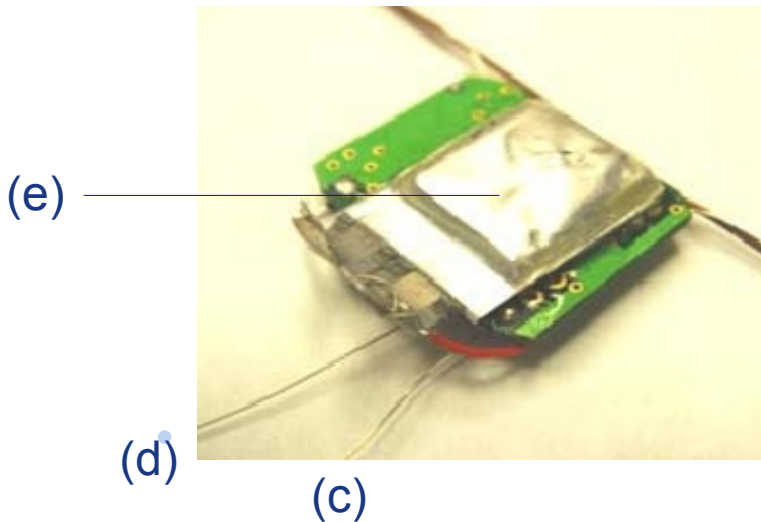
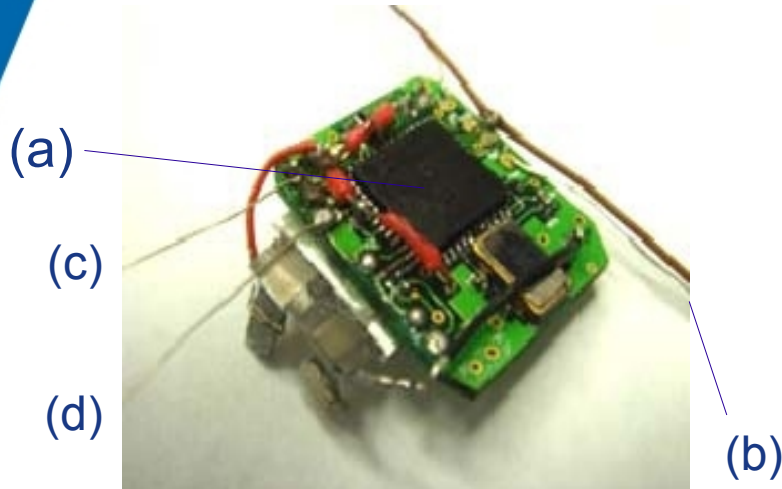
- (a) live beetle platform (Mecynorhina, 4 - 10 g, 4 - 8 cm)
- (b) RF transmitter (CC2431 microcontroller mounted on a Chipcon Texas Instruments SmartRF 04EB) operated by user's personal computer via USB/Serial-interface.

Radio-controlled cyborg *Mecynorhina* beetle



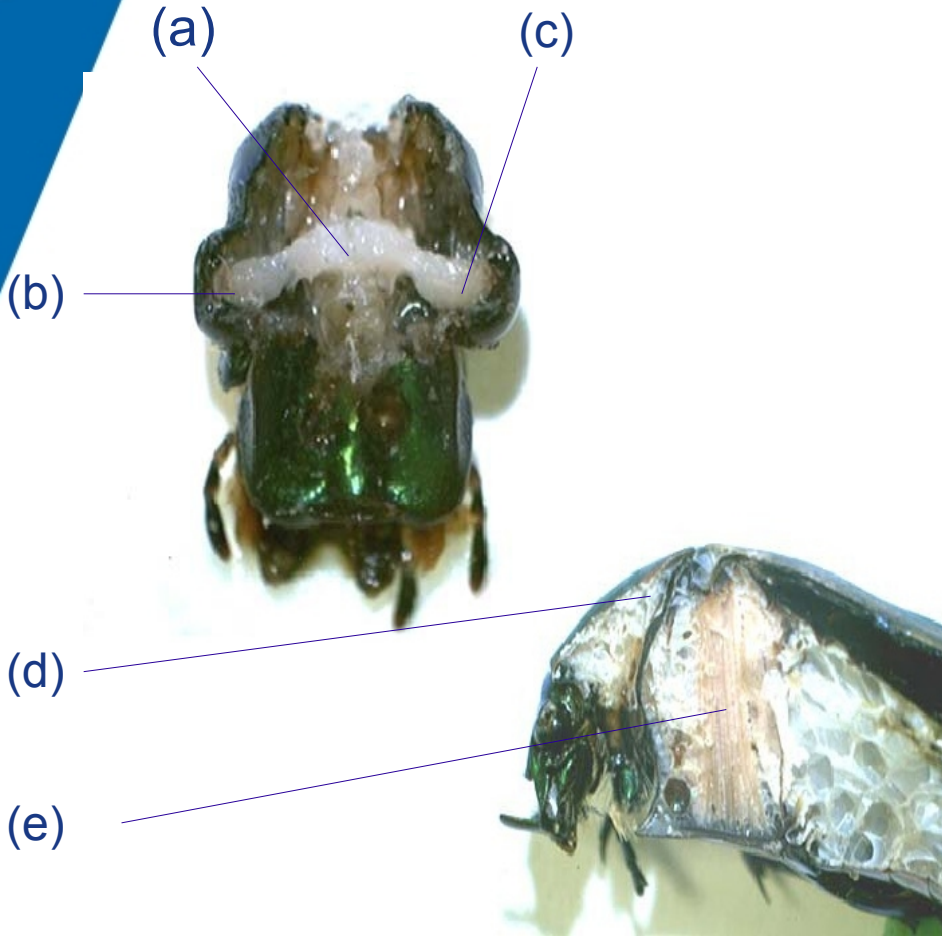
- (a) RF receiver assembly (Chipcon Texas Instruments CC2431, 2.4 GHz, on custom PCB, see also Fig. 2)
- (b) half-wave dipole antenna
- (c) stimulating electrode terminals at both optic lobes
- (d) basalar flight muscle (left)
- (e) posterior pronotum (counter electrode).

RF receiver assembly



- (a) microcontroller
- (b) half-wave dipole antenna
- (c) stimulating electrode to right optic lobe
- (d) stimulating electrode to left optic lobe
- (e) microbattery

Implant points

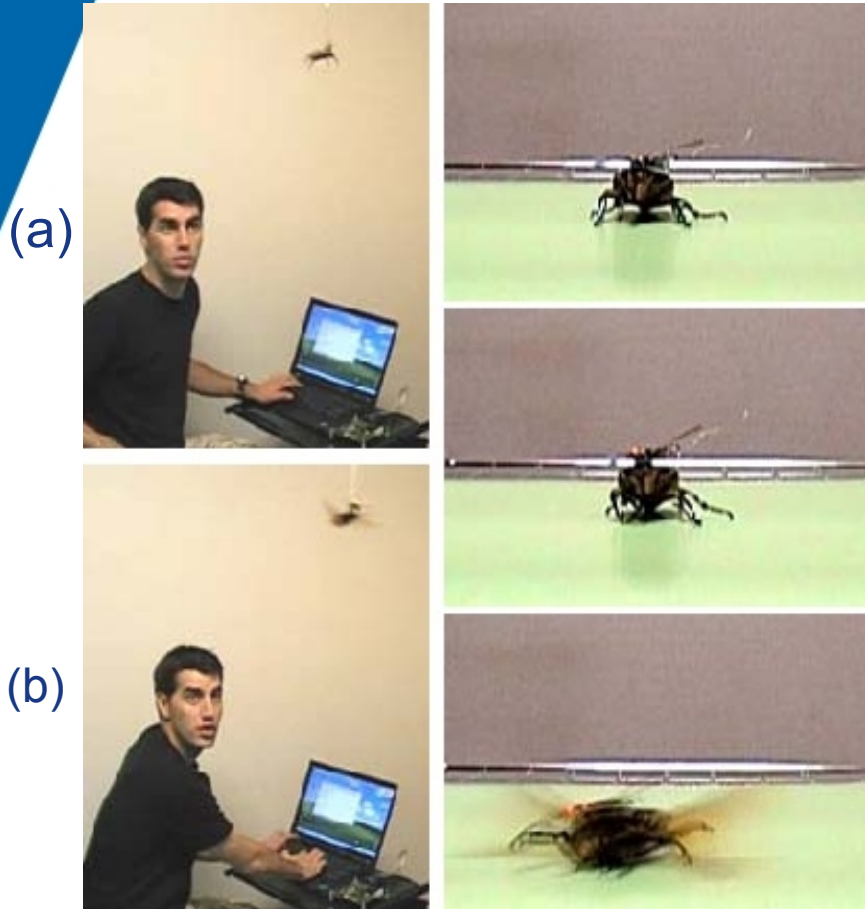


- (a) brain
- (b) optic lobe right
- (c) optic lobe left
- (d) posterior pronotum
- (e) basalar muscle (left)

Flight control

- commands were generated by software (BeetleCommander v1.0) running on a personal computer interfaced via a USB port with the transmitter(CC2431 microcontroller)
- software allowed for in-flight control of stimulation parameters including frequency, number and duty cycle of control voltage pulses to stimulated sites.
- the stimulator was wirelessly operated by user via the CC2431's built-in 2.4 GHz IEEE 802.15.4 compliant transmitter
- working range of the wireless system was ~10 m indoors; outside the range is 2 – 5 x greater

Flight initiation



- induced by the optic lobe simulator (100 Hz, 4 V amplitude, alternating positive and negative potential pulse trains between left and right optic lobes)
- (a) user signaled for initiation of flight
- (b) beetle initiated flight
- (c)-(d) close-up views

Thank you for your attention.



Resources

- http://www.eecs.berkeley.edu/~maharbiz/Sato_2009_V
- <http://www.youtube.com/watch?v=PAeV96bTRil>
- <http://www.technologyreview.com/biomedicine/22111/page1/>

