EcoBot II: An environment monitoring autonomous robot

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The ability of robots to operate with minimum human intervention, independent of the energy supply, is often enough to term an agent autonomous. However, there is a clear distinction between computational ability and energy obtainment. These have already been identified as *computational* autonomy and *energetic* autonomy [1]. Battery-operated robots, for example, demonstrate computational autonomy but not energetic, whereas solar-powered robots demonstrate both provided that sufficient energy is available.

During the past years, great emphasis has been given to computational autonomy and almost none to energetic autonomy. We would like to emphasise that for a robot to be autonomous, the two must be considered together and energy obtainment must form part of the agent's behavioural repertoire.

A robot powered by live microorganisms can utilise as fuel a wide range of organic substrates of the types found in agriculture or food wastes. This implies that robots can be designed to operate in a range of habitats where they can exploit various forms of energy sources and hence illustrate a different (perhaps higher) level of autonomy. We believe this is the first step towards a truly energetically autonomous robot.

EcoBot II, which builds on its predecessor, EcoBot I [2, 3] performs environmental monitoring, powered solely by microbial fuel cells (MFCs). It is integrated with a wireless transmitter connected to a temperature sensor, so that temperature information can be fed to a terminal that is away from the robot. The sensed and transmitted data does not have to be temperature. It can be anything that is in relation to the environment of the robot like for example, toxic levels, humidity or an indication of its internal state, such as pH, fluid substrate level etc. This can be extremely valuable in remote area access and monitoring. The robot consists of eight MFCs that suffice for both tasks, which are fed on sucrose (0.02% w/v). This is the first reported robot in the world powered by MFCs that has the ability to transmit wirelessly information about its environment.

An MFC is a *bio*-electrochemical transducer that converts *bio*-chemical energy to electrical energy, in roughly the same manner as a normal fuel cell. Microbial fuel cells fall under the proton exchange membrane (PEM) fuel cell category, since that is the solid electrolyte used in the system. The MFCs used for this line of experiments were of identical design and structure to the ones previously used for EcoBot I. The difference in these fuel cells was the *bio*catalyst employed, i.e. the culture of microorganisms. In this case it was decided to employ sewage sludge obtained from anaerobic activated samples (Wessex Water Scientific Laboratory). The choice of this microcosm proved to be advantageous for a number of reasons some of which are ease of preparation, growth media and substrate diversity, and unmodified physicochemical conditions. Furthermore, MFCs incorporating sewage sludge are producing as much as 10 times more power than that produced by the MFCs using *E. coli* and mediator. Figure 1 below shows a picture of the EcoBot II.

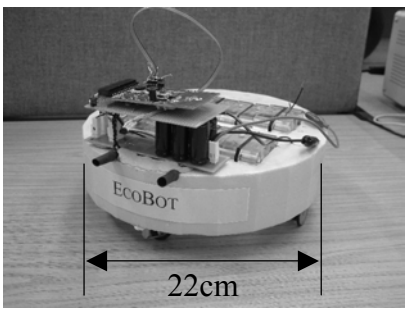

Figure 1. EcoBot II fully assembled with the wireless transmitter and temperature sensor on top.

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