***Exoskeleton Robotics***

**The Pentagon is Trying to Develop Robotic "Muscle-Suits"**

**Muscle Power Dressing for Super Troopers**
by Adam Sherwin

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A GIANT leap for mankind may have begun with one small flip of a robotic fish. The fish is the first robot to be powered by real muscles and American military chiefs believe that the same technology could be harnessed to enable soldiers to leap tall buildings.

The Pentagon is trying to develop robotic "muscle-suits" to give more power to a soldier's natural movements. Like Steve Austin, the bionic man played by Lee Majors in the 1970s television series The Six Million Dollar Man, anyone wearing such a suit would be "better, stronger, faster".

In research funded by the military, scientists at the Massachusetts Institute of Technology built a robot fish that swam using live muscle tissue taken from a frog.

The leader of the research, Hugh Herr, has a special interest in the project. An attack of frostbite cost him both his legs below the knee, and he believes that his work could lead to improvements in artificial limbs.

The robotic fish worked by using a microprocessor that sent electric signals to frog muscles on either side, making them contract, New Scientist magazine reports. Tendons on the muscles were sewn to the nose and tail and the robotic fish wiggled and swam in response to the signals. The muscles took their energy from a glucose solution in which the fish swam.

The next step is to create another prototype that contains its own nourishing glucose. Bigger muscles would need an artificial circulatory system to pump the glucose to them.

The Pentagon is spending $50 million (£34.7 million) on developing the muscle-suits in which real muscles would activate the robotic components.

A spokesman for the Pentagon's Defence Advanced Research Projects Agency said: "The idea would be some kind of exoskeleton that would allow a soldier to have increased strength, increased endurance, increased speed."

The soldier would wear it as an outer skin, rather than operate it, and its functions would optimally become an extension of the soldier's natural movements. The suits, fully equipped with computers and communications gear, would run on a compact power generator that would provide 24 hours of continuous use.

Agency documents claim that the suits will "augment human strength" and allow soldiers to "leap extraordinary heights and distances". The Pentagon plans appear to be influenced by the mobile combat suits used to fight alien bugs in the 1997 film Starship Troopers.

Civilians could also feel the benefits. Artificial limbs tend to be stiffer than real ones and cannot adapt to different surfaces. Prototype limbs currently contain noisy joint motors. Dr Herr said: "If all our muscles were motors, we wouldn't hear ourselves talking."

His next step is to improve the prototype robot by giving it a small stomach to contain the nourishing glucose. Bigger muscles would need an artificial circulatory system to pump the glucose to them.

As long ago as 1786, Luigi Galvani discovered that electricity made a dissected frog's leg twitch. But until now, nobody has tried to apply the concept to power a machine. Dr Herr's original robot has now expired, since its muscles would keep only for a few hours.

Another American team is reported to have succeeded in growing artificial muscle cultures that live for several months. Bob Dennis, from the University of Michigan, and his colleague Paul Kosnick, have persuaded human muscle fibres to grow in the laboratory by stimulating them electrically. It is the first time that human muscle has been grown artificially.

The pair believe that the technique might make some animal tests redundant because chemicals could be tested on muscle cultures. Although the muscles survive three to five months, compared with only a few hours for natural muscle removed from the body, they are only a tenth as strong as the real thing. Yoseph Bar-Cohen, who heads Nasa's advanced actuators laboratory in Pasadena, California, admitted: "There are issues of robustness with these artificial muscles. They oxidise easily."

Bob Dennis, a colleague of Dr Herr, was sceptical. He said: "Why would anyone want to build artificial muscle? Real muscle can adapt to its environment, it can heal itself and it can self-regulate."

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