JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# XENOBOTS-WORLD'S FIRST LIVING ROBOTS USING ARTIFICIAL INTELLIGENCE

**[1]Ms Sumi M, [2]Sneha K**

[1] Assistant Professor, [2]MCA Scholar
[1]Department of MCA,
[1] Nehru College of Engineering and Research Centre, Pambady,Thrissur, India
sumimurali118@gmail.com , snehaksuresh3005@gmail.com

**Abstract *:*** Xenobot is a living, cell-based robot. Evolutionary algorithms running on a supercomputer design its configuration and movement style. Xenobots are tiny self-healing biological machines made from frog cells that can move around, push a payload, and even exhibit collective behaviour in the presence of a swarm of other Xenobots, according to a team of biologists and computer scientists from Tufts University and the University of Vermont (UVM). A xenobot, unlike other robots, is extremely tiny. Metal, plastic, or other synthetic materials are not used. It's totally made up of biological cellular substance.

***IndexTerms* –** Xenobot, Artificial Intelligence

## I. INTRODUCTION

According to a group of biologists and computer scientists from Tufts University and the University of Vermont, Xenobots are tiny self-healing biological machines constructed from frog cells that can move around, push a payload, and even demonstrate collective behaviour in the presence of other Xenobots (UVM). Xenobots are much smaller than other robots. There is no usage of metals, plastics, or other manmade materials. It is formed entirely of biological cellular matter.[5]

The same group has now created living organisms that can self-assemble a body from single cells, move without using muscle cells, and even remember things. The current generation of Xenobots can also travel faster, traverse a wider range of environments, and survive longer than the original edition, and they can still work in groups and heal themselves if injured.

Unlike the first generation of Xenobots, which built millimeter-sized automatons by physically putting tissue and surgically manipulating frog skin and heart cells to generate motion, the second generation of Xenobots took a "bottom up" method. Tufts biologists used stem cells from Xenopus laevis (thus the name "Xenobots") embryos to self-assemble and grow into spheroids, where part of the cells differentiated into cilia – tiny hair-like projections that move back and forth or spin in a certain way after a few days. The new spheroidal bots use cilia to give them "legs" that allow them to move quickly across a surface, rather than manually created cardiac cells, which allowed the original Xenobots to scamper around due to their natural rhythmic contractions. Cilia are found on frog and human mucosal surfaces, including as the lungs, to help push pathogens and other undesired material out. They've been upgraded to allow them to attack the Xenobots more swiftly.

## II. THE EVOLUTION OF XENOBOTS

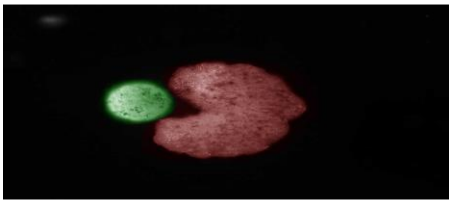

figure 1 : A xenobot (c shape; red) developed by ai cleaning up stem cells packed into a ball.

### Motivation for Creating Xenobots

Researchers were experimenting with the notion of controlling real-life cells to behave exactly how they want, similar to other robots that have been built in recent years. Tufts University and the University of Vermont researchers extracted stem cells from an African clawed frog embryo (Xenopus Laevis). Skin cells and heart cells were among the stem cells collected by the researchers.

The capacity to relax and contract was chosen for skin cells, whereas the tendency to spontaneously bind was chosen for heart cells. The concept was to mix skin and cardiac cells in a certain way to create a functioning structure with locomotive skills. That was the goal of the researchers: to create an organic robot with a particular movement style.

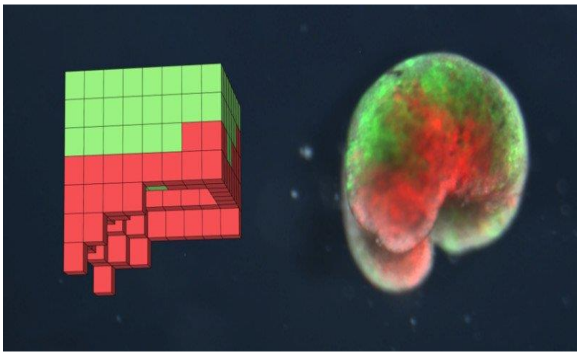

figure 2 : modeled xenobot (left), real xenobot (right), (photo credit : sam kriegman,uvm)

**Xenobot Modellig with Supercomputers & Evolutionary Algorithms**

The initial step in creating a xenobot was feeding recorded data from stem cells into a supercomputer's evolutionary algorithm. The supercomputer quickly created millions of cell combinations based on this information, which researchers could then examine for the intended result. Natural selection was utilised to configure a xenobot that looks like a biological creature using evolutionary methods.[1]

The goal of the first xenobot's researchers was to accomplish the ideal form of movement. As a result, only the best configuration capable of producing the necessary movement progressed to the next round of development. Only a few computer-generated combinations were picked after hundreds of experiments to get the setup perfect.

Researchers were ultimately succeeded in developing a blueprint for a new life form by combining the power of supercomputing with evolutionary algorithms.

**Sculpting Using Tweezers and Forceps**

Researchers meticulously performed microsurgery using tiny forceps and tweezers under a microscope to convert the computer-generated design into reality. Researchers had to link one cell to another one at a time until the ultimate structure of 2000 cells was created. Fortunately, cells have a natural desire to cling together, giving researchers an advantage. Nonetheless, considering the thousands of cells involved, it was a time-consuming and arduous operation. The assembling of cells was completed after many hours of labour, and a new organism was born[1]

## III. FEATURES OF XENOBOTS

These freshly formed xenobots may move in circles or propel themselves in a straight path. Xenobots of the first generation could only live for around 7-10 days, but because they are formed of living cells, they can mend themselves throughout their lives. Even after being ripped in half, they were able to recover!

**Xenobots' Emergent Behavior**

Certain activities are impossible for a single cell to do, but they may be accomplished when numerous cells are gathered together. We human beings exemplify this behavioural change from a single cell to a multi-celled structure. Our bodies contain trillions of cells, yet none of them have their own awareness. However, awareness occurs when they are combined in a certain structure, such as the body.

Despite the fact that the first-generation xenobot has two thousand cells, we expect to scale them higher in the future. Many experts anticipate that emergent behaviour will manifest itself in more noticeable ways at this time.

**Now with Memory**

The capacity to record memories and utilise that knowledge to adjust the robot's movements and behaviour is a key characteristic of robotics. Tufts scientists used a fluorescent reporter protein called EosFP, which typically glows green, to construct the Xenobots with a read/write capacity to record one piece of information. When exposed to light with a wavelength of 390nm, however, the protein produces red light instead.

Before the Xenobots were created, the cells of the frog embryos were injected with messenger RNA coding for the EosFP protein. The adult Xenobots now have a fluorescent switch built in that can track exposure to blue light about 390nm.

The memory function was tested by enabling 10 Xenobots to swim across a surface with one location lit with a 390nm laser beam. They discovered three bots emitting red light after two hours. The rest kept their original green colour, thus capturing the bots' "journey experience."

This molecular memory proof of principle might be developed in the future to detect and record not just light, but also radioactive contaminants, chemical pollutants, medications, or a medical condition. More work on the memory function might allow the bots to record numerous stimuli (more bits of information) or release substances or modify behaviour in response to inputs.

"When we give the bots greater capabilities, we can utilise computer simulations to develop them with more complicated behaviours and the capacity to carry out more elaborate jobs," Bongard explained. "We might theoretically build them to not just report on issues in their surroundings, but also to change and fix those circumstances."

**Xenobot, Heal Thyself**

"The biological materials we're utilising have a lot of qualities that we'd like to include into the bots in the future," Levin said. "Cells can operate as sensors, motors for movement, communication and computation networks, and recording devices to keep information." "One thing the Xenobots and future generations of biological bots can do that their metal and plastic counterparts can't is create their own body plan as the cells grow and mature, and then heal and restore themselves if they become harmed," says the author. Healing is a natural component of living beings, and Xenobot biology has conserved it."[3]

The new Xenobots were exceptionally good at mending, and after 5 minutes of being injured, they could close the majority of a serious full-length cut half their thickness. All of the damaged bots were eventually able to repair their wounds, regain their form, and resume their employment.

Another benefit of a biological robot, according to Levin, is metabolism. Biological robot cells, unlike metal and plastic robots, can absorb and break down chemicals and operate as little factories generating and excreting chemicals and proteins. Synthetic biology, which has mostly concentrated on reprogramming single-celled organisms to make valuable chemicals, may now be used to multicellular species.

The enhanced Xenobots, like the original Xenobots, can execute their jobs without extra energy for up to ten days on their embryonic energy stores, but they may also work at full speed for months if maintained in a "soup" of nutrients.

**Self-Replication**

Most creatures in nature reproduce by either mating and generating offspring or cloning themselves. However, a new mechanism of propagation has emerged: living robots that can self-replicate by groping cells and producing offshoots.

Engineers and computer scientists from the University of Vermont, Tufts University, and Harvard University used artificial intelligence to evaluate several body designs for their living robots. They noticed that the small cell clumps were most efficient at self-replicating when they had a Pac-Man-like C-shape.

When the researchers suggest the bots can self-replicate, they don't always imply they do so. What they imply is that the cluster in that C-shape configuration can push itself across a petri dish using hair-like cilia on the exterior of each cell. The cluster catches additional stray cells and bundles them together till they create their own xenobot as it goes. However, this procedure does not last indefinitely. This was only possible for a few generations of xenobots because to thecells.[3]

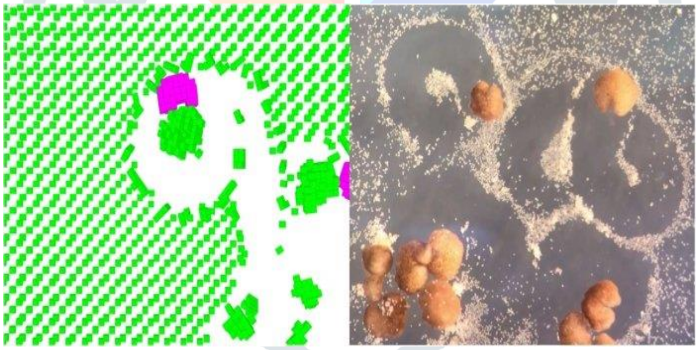

figure 3 : Xenobot self replication

## IV. FUTURE APPLICATIONS OF XENOBOTS

The Xenobots have various promising applications for the future. Here are some of them:

**Detecting Cancer Cells And Unclogging Arteries**

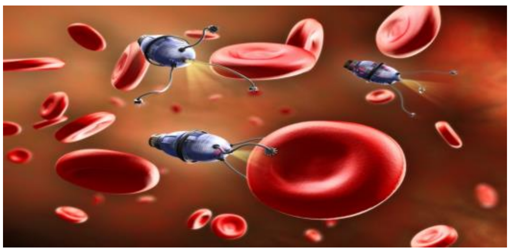

figure 4: Medical science is expected to be revolutionised by xenobots.

Advances in xenobot technology are expected to benefit the medical industry the most. Scientists may build xenobots in the future to identify and combat cancer.

Scientists are currently confronted with the issue of eradicating tumorous cells because when they implant a foreign object to operate on the tumour, the body detects it as a foreign body and initiates an immune reaction.

This immune response has the potential to complicate overall cancer treatment. It is feasible to create xenobots from the cells of the real patient. When xenobots are implanted into the body to identify and eliminate tumorous cells, the body will not consider them as an alien organism, avoiding undesired immune reactions.

Similarly, xenobots might be used to unclog harmful blockage in the arteries of heart patients. Xenobots would be a breakthrough factor in the medical industry even if they only served these few tasks.

**Cleaning Oceans and Environment**

figure 5 : Xenobots detecting waterbodies

These bio-bots' applications aren't simply restricted to the medical area. Xenobots have the potential to save the planet.The seas and other water bodies of the globe have been significantly contaminated as a result of increased industrial activity over the last several decades, as waste products from industries and factories have been irresponsibly thrown into the oceans and other water bodies. As a result, aquatic bodies are littered with microplastics that are difficult to recycle or process.

Scientists may be able to construct xenobots that can identify and break down microplastics in the future. If not, they may group them together and gather them. These xenobots might perhaps be utilised to identify radioactive pollutants in the seas or other questionable locations

**Detecting Harmful Substances**

In advanced studies, it was observed that Xenobots can be programmed to exhibit ‘molecular memory’. In the future, this can possibly be used to detect harmful substances in the environment like pollutants, drugs or diseases.

## V. XENOBOTS:AN ETHICAL CONFLICT

Now, while xenobots that save the globe sound like a great concept, there are some drawbacks. Xenobots are neither machines nor animals, when you think about it. They're something different in the middle. As a result, it's possible that we'll have to rethink how we classify living and non-living things.

While the current generation only has cells from the skin and heart, future generations of xenobots might include cells from the neurological system, blood arteries, or even reproductive organs, according to researchers. These additions compel us to redefine what we mean by "life." Michael Anderson, a machine ethics specialist, argues that applied ethicists should be involved at the early phases of the creation and growth of these fundamentally new forms of life in order to design their duties and rights.

After all, once these xenobots have matured enough to acquire cognitive capacities, we'll need a framework that clearly outlines their jobs and responsibilities.

These ethical difficulties have been noted by researchers working on the first-generation xenobots, who have referred to them as "uncharted territory." People are welcome to attend and explore the future ramifications of this new generation of bots. This allows even the general population to grasp what is going on. Policymakers can develop better regulations for regulating them and ensuring that we accomplish something positive with this wonderful technology by engaging in the dialogue.

## VI. CONCLUSION

These tiny biological robots can be useful in environmental tasks or potentially in therapeutic applications, and bots can be useful in laying the groundwork for regenerative medicine by demonstrating how individual cells come together, communicate, and specialise to form a larger organism, as they do in nature to form a frog or human. The Xenobots could also help researchers learn more about cell biology. It will lead to future advancement in human health and longevity. As biological machines, Xenobots are very environmentally friendly and safe for human health.

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