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ADVANCED EMBEDDED SYSTEM DESIGN IMPLEMENTATION IN ARTIFICIAL INTELLIGENCE

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Abstract— **The technology of programmable matter or catoms is one of the most revolutionary concept in the history of electronics and computers. Developed by researchers Seth Goldstein and Todd Mowry the field of claytronics is all set to replace Nanotechnology from the origin of electronics. The catom is known to be an individual modular robot which works in groups of millions to provide fictional properties such as color changing or shape changing according to their corresponding catoms. Due to this property of catoms it offers dynamic physical rendering that result in these tiny micro-robots to change any shape depending on their environment. Due to the availability of millions of catoms in a single ensemble it is very difficult to have a global planning system to control all these robots. Hence the scientists are trying to find a way enabling the catoms to change shape without having a global planning system.**

Index Terms—**About four key words or phrases in alphabetical order, separated by commas.**

I. INTRODUCTION

When the world's first working computer was invented, it seemed to be a big room size machine with lots of vacuum tubes and air condition facilities. But in recent 50 years the size of a computer has been shrunk from room size mainframe computers to a light weight desktop. This comprises of using the latest technology of transistors and integrated chips where thousands of transistors can be implemented. This miniaturization leads to a high volume nano-scale manufacturing of computers. This high volume fabrication of nano scale computers leads to production of millimeter scale units that integrate themselves and perform functions like sensing, computing, actuation and locomotion mechanisms. This collection of several millimeter scale units is known as programmable matter.

II. CLAYTRONICS

The technology of claytronics and programmable matter is an effort of researchers at Carnegie Mellon University followed by Intel Research Pittsburgh that will bring a revolution in the electronics technology of today. The concept of programmable matter mainly focuses on creating an exact replica of the matter present around us. As the audio and video technology around us capture the sound and video around us and reproduce it via audio or video medium, similarly our programmable matter design will capture the image of the object in 3dimension and reproduce it with same functions as the original perform. The basic idea behind the claytronics technology is neither to transport an object's original instance nor the recreate its chemical composition, but rather to create a physical artifact using programmable matter that will eventually be able to mimic the original object's shape, movement, visual appearance, sound, and tactile qualities.[1]

2.1 REPRODUCE THE REALITY

The basic application of the catom technology is to create an ensemble which comprises of millions of nano-scale robot modules which work cooperatively with the help of programming to self-assemble into arbitrary 3D shapes. But this might only be a start. The further advancement in the technology of catoms enables the researchers to use such ensembles to achieve synthetic reality, an environment that allows for the physical realization of all computer generated objects. This physical realization doesn't require any sensory instruments such as head mounted displays or any goggles. They can also physically interact with any object in the system in the natural way.[2]

2.2 WHAT IS A CATOM?

The collection of such individual units that that work together based on a specific program to perform functions such as shape changing, color changing is known as programmable matter or catom. The basic properties that made the programmable matter so unique are:

1. Catoms can move in three dimensions in relation to other catoms
2. Catoms can adhere to other catoms to maintain a 3D shape
3. They can communicate with other catoms in an ensemble and
4. They can compute state information with possible assistance from other catoms in the ensemble.

In the preliminary designs, each catoms is a self contained unit that comprises of:

- A CPU.
- An energy store such as onboard battery.
- A network device.
- A video output device such as LCD or LED.

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- Sensors like pressure sensors and photo sensors.
- A means of locomotion
- A mechanism for adhering to other catoms.[4]

Fig1 Claytronics atom prototypes. Each 44-mm-diameter catom is equipped with 24 electromagnets arranged in a pair of stacked rings.

In the present macro-scale design which is 44mm in diameter, shown in Fig1, each catom is equipped with 24 electromagnets arranged in a pair of stacked rings that allowed them to move with respect to each other. According to this design the time taken for a step reconfiguration involving uncoupling of two units, movement from one pair of contact points to another, and re-coupling at the next pair of contact points. The resulting force from two similarly energized magnet coils varies roughly with the inverse cube of distance, whereas the flux due to a given coil varies with the square of the scale factor. Hence, the potential force generated between two catoms varies linearly with scale. Meanwhile, mass varies with the cube of the scale. Hence it is concluded from the above relationships that a 10 fold reduction in size should translate a 100 fold increase in force relative to mass. However supplying power to the ensemble is still an issue.

2.3 POWER GENEARATION IN CATOMS

One idea is to provide static power to the whole ensemble consisting of catoms. But that doesn't work when the catoms are motionless and still they need external power supply for strong bonding between the layers of two catoms. Therefore scientists are developing a technology for routing energy from an external source to all catoms in an ensemble. These catoms consist of a tube that is fabricated as a double layer planar structure in 2D using standard techniques of photolithography and a high voltage self-contained CMOS device that is fabricated separately and then manually wired bonded to the tube.

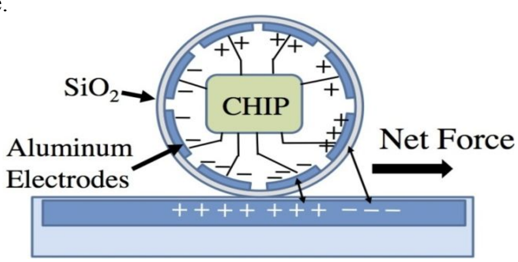

Figure 2: Motion generation in nano-scale catoms.

This CMOS device includes an AC-DC converter, a storage capacitor, a simple logic unit, and output buffers. The catom moves on a power grid (the stator) that contains rails which carry high voltage AC signals. Through capacitive coupling, an AC signal is generated on the coupling electrodes of the tube, which is then converted to DC power by the CMOS chip. The powered chip then generates voltage on the actuation electrodes sequentially, creating electric fields that push the tube forward. [5]

III. SHAPE CONTROLLED WITHOUT GLOBAL POSITION PLANNING

In the previous approach of shape changing catoms we need motion planning in a high dimensional search or a global planning of how each catom will interact with other. But with millions of catom in a single ensemble the global planning approach will face some difficulty as the instructions used are very high. Further a global plan will break down in case of one unit failure. To overcome this problem, researchers are trying to build a new set of algorithm that can control shape without any need of extensive planning. Though this is just a beginning, the researchers at Carnegie Mellon University have found an early success using the technology of semiconductor physics. This approach focuses on the motion of holes rather than that of robot.

A hole is defined as a circular void which is created due to the absence of seven catoms from a given hexagonal plane of catoms. Such a seven catom hole can migrate through the ensemble by appropriate local motion of the adjacent catoms. Holes migrate through the ensemble as if moving on a frictionless plane, and bounce back at the ensemble's edges. As the above figure suggest edge can contract by consuming a hole or expand by creating a hole, purely under local control. This shape formation process is initiated by creating such holes in the ensemble. As soon as these holes are created they gain an independent, random velocity begins to move around. A shape goal specifies the amount each edge region must either contract or expand to match a desired target shape. [7]

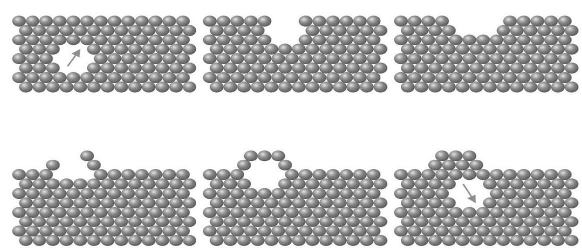

Figure 3. Hole motion. Edges can (a) contract by consuming a hole or (b) expand by creating a hole, purely under local control.

As the figure suggests, a hole when hit by a contrasting edge is consumed. In effect the empty space that constitutes the hole would be filled with the surrounding catoms in that particular edge region. Similarly when a hole is create at the edge of an ensemble it is pushed inside the ensemble pushing the corresponding catoms out in the local region. The most important thing is that all edge contouring and hole motion can be accomplished using local rules, and the overall shape of an ensemble can be programmed purely by communicating with the catoms at the edge. Hence we use probabilistic methods to achieve a deterministic result. Our initial analyses of the corresponding 3D case suggest surface contour control will be possible via a similar algorithm.

CONCLUSION

The initial research in the field of claytronics suggests that it may possible to construct power and control large micro-robot ensembles to model 3D scenes. While many difficulties remain, successful implementation of a dynamic physical rendering system could open the door to a new era of human-computer interface design and new applications. Economic feasibility also poses a high bar to the manufacture and deployment of multimillion-robot ensembles. Achieving the Claytronics vision won't be straightforward or quick, but by taking on some of the problems associated with operating and building these ensembles, we hope to advance the state of the art in modular reconfigurable micro-robotics and encourage others to undertake related research.

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