# REPORT ON EXISTING MODULAR ROBOTS & SCOPE OF RESEARCH

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## What is a Modular Robot?

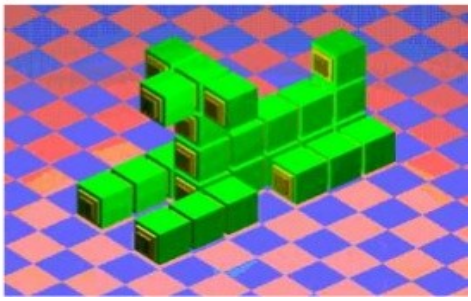
Self-reconfigurable modular robots are autonomous robots with a variable morphology, where they are able to deliberately change their own shapes by reorganizing the connectivity of their modules to adapt to new environments, perform new tasks, or recover from damages.

### *Classification* according to the geometric arrangements of the modules

**Architecture**

- **Chain Architectures:**
  - Modules are connected together in a string and tree topology.
  - Motion controls of the modules are executed sequentially.
  - Easier to design and implement.

- **Lattice Architectures:**
  - Modules are connected in some regular, space filling 3 D pattern.
  - Control and motion are executed in parallel.
  - More flexible and efficient to form complex structures.
  - More suitable for dynamic environments.



### Classification Based on Number of different modules used can be classified as

**Homogeneous and Heterogeneous Reconfigurable Robots**

**Homogeneous**

- All modules are all the same
- Module position determines role
- Less-costly hardware/software design process
- Simple to reconfigure

**Heterogeneous**

- Can have different modules
- Function of module determines role
- Many different hardware/designs – costly
- Complex reconfiguration

**EXISTING MODULAR ROBOTS**

## Chain: CKBot System

- The CKBot system is a reconfigurable robotic system developed by Yim at the University of Pennsylvania.
- These modules utilize a servo to rotate one portion of the module with respect to the other.
- Global inter-module communication through CANbus as well as local neighbor-to-neighbor communication is incorporated on the modules. This system has also been used in some experiments in self-repair.

## Lattice: Atron System

- The Atron system reconfigures in a lattice system, but can form chains as well. This image shows a four "legged" or "wheeled" configuration depending on how the modules are actuated.
- Modules can distribute power via their bonding mechanisms and use a power management system for voltage regulation and battery charge maintenance.
- A module consists of two hemispheres where one can rotate continuously relative to the other.
- Reconfiguration is performed by having one module grab another and then rotate some multiple of 90 degrees to another position in the lattice structure.

| 2D Modular Robots | Homogeneity/ Heterogeneity | Dynamic Motion | Comments |
|---|---|---|---|
| CEBOT (Nagoya Univ.) | Hetero | No | A modular robot proposed first |
| Fractum (AIST) | Homo | No | First exmeriment of self-repair |
| Mirco-module (AIST) | Homo | No | Micro-sizing into 2cm cube using SMA |
| Metamorphic Robot (Johns Hopkins Univ.) | Homo | No | Hexagonal link mechanism |
| Modular robot of Riken | Homo | No | Cube-shape, can be stuck vertically |

| 3D Modular Robots | Homogeneity / Heterogeneity | Dynamic Motion | Self-reconfigurability | Control System | Comments |
|---|---|---|---|---|---|
| 3D Self-reconfigurable Structure (AIST) | Homo | No | Yes | Centralized | First 3D self-reconfigurable homogeneous modular structure |
| Crystaline (Dartmouth) | Homo | No | Yes | Centralized | Shrinkable module to build 2D and 3D structures |
| Moledule (Dartmouth) | Homo | No | Yes | Centralized | Composed of a link and two connecting parts |
| I-Cube (CMU) | Hetero | No | Yes | Centralized | Consists of two types of modules, links and cube. The link is actuated |
| CONRO (USC) | Homo | Yes | Yes | Centralized | Serially connected modules with small degrees |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | of freedom for dynamic motion |
| Polybot (Xerox PARC) | Homo | Yes | Yes | Centralized | Serially connected modules with small degrees of freedom for dynamic motion |
| 3D Modular Structure (TiTech) | Homo | No | Yes | Centralized | Reconfiguration performed by pneumatic actuator |
| RBR (TiTech) | Hetero | Yes | Yes | Centralized | Reconfigurable robotic arm for space applications |
| "Modular Transformer" MTRAN (AIST) | Homo | Yes | Yes | Centralized | Succeeded in moving by changing its locomotion mode using 9 modules |
| SkyWalker (CMU) | Hetero | Yes | No | Centralized | An example of modular space robot |
| Tetrobot (Renssaeler Polytech. Inst.) | Hetero | Yes | No | Centralized | An example of a modular robot with many possible configurations |

## CONCLUSION

After going through various modular robots(mentioned in the table),

The Scope for Research are:
- There is a need for interfacing of Sensors to Modular Robots.
- Programming them with Sensor Feedback.
-Making them interactive with the environment.

This can be efficiently, timely and proficiently done using Dtto Modular Robot because,
1) It has already provided free space for Sensor Attachment
2) Design and code  is open source (for initial reference)
3) It is inspired from MTRAN
4) IR, Proximity, Gyro Sensors can be easily attached to each module
5) Modules are homogeneous
6) Thus program one program all

## REFERENCES


1) http://thesis.library.caltech.edu/4189/1/Chen_im_1994.pdf
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