Group Morphogenesis, Report Week 1

Wenguo, Ronny, Michele, Christopher, Yao-yao

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1 Goal

The goal is to decide among various shape representations, and to assess them along different criteria.

2 Candidate representations / Partners

2.1 Wenguo (Bristol)

Explicit representation, grammar-like
Tested in simulation: organism construction completed
Issue: evolvability

2.2 Ronny (Graz)

Virtual embryogeny, AHHS
Each module of the organism exchanges signals (hormone levels ?) and surface module can recruit additional free cells
Tested in simulation () and on robots (how many)
Issue: size of the representation

2.3 Michele (Paris)

Virtual embryogeny, cellular automaton
Each module of the organism emits signals and surface modules can recruit additional free cells
Tested in simulation () [PhD Alexandre Devert]
Issue: convergence toward controllable-size organisms

2.4 Christopher (Tubingen)

Helps Wenguo to devise structured variation operators (mutation, crossover)

2.5 Yao-yao (Gent)

Virtual embryogeny, regulatory gene network
Tested in simulation[1].

3 Criteria

Let F denote the mapping from the representation space R to the shape space S.

3.1 Viable shapes

Not every shape in S is admissible.

A viable shape must satisfy some domain-dependent criteria; here we only require it to involve among 4-10 modules.

TBC: another criterion might also be its dockability (e.g. putting a module at the internal corner of an L might be infeasible in practice).

3.2 Properties of the mapping genotype to phenotype

Is the mapping deterministic ?

If stochastic, the mapping should be one to reasonably few (few phenotypes for one genotype).

The mapping should be invertible (**controllability**) in the sense that a given shape (I, H, X) must be representable in the target representation.

Ratio phenotype / genotype (if 1, deterministic) Time needed to generate a genotype from a phenotype

3.3 Initialization

Generate random elements in the representation space. Do they correspond to viable shapes ? Do they correspond to diverse[2] shapes ?

Curve: Number Y(X) of trials needed to yield X viable and diverse shapes Time needed

3.4 Variation operators

Generate offspring of viable parents. Do they correspond to viable shapes ? Do they correspond to diverse shapes (from their parents) ?

Averaged over several parent couples:

Curve: Number Y(X) of trials needed to yield X viable and diverse shape offspring from viable parents Time needed

[1] Please complete which simulator.

[2] Here a notion of what means being different is missing.

4 Experimental setting

Every result should be accompanied with some details:

- Simulator (which one) or robots (which ones)
- Initialization (from fixed shape alphabet or from random)
- Loop
  - Apply variation operators
  - Fitness = number of new viable shapes offspring
  - Select random individuals in the offspring

Report average number of viable shapes generated in each generation.

4.1 Later

Fitness will be enriched with other criteria. See group "Internal Rewards".

4.2 Simulators

Wenguo's framework is available (sent by mail on Nov. 5th).
Others ?

5 WENGUO

5.1 On representation of organism structures

Our morphogenesis strategy relies on some specified organism representations. The already developed symbol sequence representation can only be applied on a homogenises[3] system and comes with certain limitations. To address these issues, we will

- Improve the design of structured sequence representation by taking the following two facts into account: a) a robot can move and dock to another robot from any side, instead of FRONT side only, and b) an organism is made of different types of robots: KIT, Scout and AW, instead of identical modules.
- Design of crossover and mutation operators for evolutionary partners over the structured sequence representation. This will enable evolution happen in two different cases: 1) prior to the self-assembly, different shapes can emerge from evolution process, and 2) during the morpho- genesis, recruiting robots can evolve their sub-shapes, however, similar to the implicit approach, this requires an organism structure finding process afterwards.

Expected output by the end of November, 2011:

- A library provides functions to access to the structured sequence representation, such as, a) loading and generating structured sequence representation from graph based data, b) generating randomised organisms automatically, c) crossover and mutation operator, d) representation validation checking function;
- Visualisation of the representation for debugging purpose, i.e. con- verting a structured sequence representation to a graphic based 2D organism
- A simple example to test evolutionary operators.

5.2 On morphology control strategy

The effort in this subtask will be more engineering focused. It includes

- Improving the morphogenesis controller design to accommodate all changes proposed in subtask 1;
- Design of an adaptive morphology control strategy in order to improve the efficiency of the assembly process. We will work closely with the current capabilities of the hardware, in particularly the interference of the IR signals and low bandwidth of the IR communication (no IrDA will be available).

The expected output: Integrated controller with evolutionary partners for the final simulation demo in February, 2012.

[3]Don't understand

6 RONNY

UniGraz will investigate following topics regarding Virtual Embryology within the next month:

- Onboard-evolution of given bodyshapes in the Symbricator-simulator.
- Evolution of shapes, beginnig with one shape of the "initial alphabet" (e.g.: "I")
- Evolution of features: e.g., "something that has limbs"
- Evolution of Combined features: The same genome steers individual robots & controls building process of robotic organism.

The experiments will be done on "toy-simulators", the SymbricatorSim and Hardware, depending on what is available.