FloT: A Framework for Self-Adaptive and Self-Organizing Internet of Things Applications

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Roadmap

- Motivation
- FIoT
  - Main Idea
- Application Scenario
  - Decentralized Car Traffic Control
MOTIVATION
Motivation

- Internet Of Things (IoT)
  - “Billions of things and events connected.”
  
  - “The Internet of Things represents an evolution in which objects are capable of interacting with other objects.” [IBM; 2013]

Fonte: ReadWrite. 2013
Motivation

- On the last years, numerous IoT research and application projects have been done by universities or in industry
  - Most of them are concentrating on operational technology
    - Limit Internet traffic capacity
    - Architecture
    - Protocols
Motivation

On this way, a lot of questions are still opened:

- How should these data be managed?
- How to define the best way to communicate all these things?
- “How can the system use this information to make inferences over context?” [Velloso, Raposo, Fuks; 2010]
Motivation

- Some researchers concentrating only on operational technologies may be a clear drawback.

- Artificial Intelligence (AI) methods and techniques can help to accomplish important tasks from IoT environment:
  - Interpreting the environment’s state;
  - To represent entities in the environment;
  - To make inferences over the context in order to make decision; and
  - Acting on the environment.
Motivation

- Multiagent Systems (MAS) are especially good to design real-world and social systems.
- It’s almost impossible to correctly determine the repertoire of behaviors on a MAS at design time.
  - “This complexity can be reduced or prevented by providing agents with learning capabilities” (WEIß, 95)
Proposed Solution

- FIoT = MultiAgent Systems + Machine Learning + Internet of Things
Framework for Internet of Things

FIOT
Main Idea

- Development of decentralized controllers for Internet of Things
- The application consists of the development of three kinds of agents:
  - God Agent;
  - Adaptive Agent;
  - Observer Agent.
Main Idea
Main Idea
## FIoT: Core

- **Devices Connection**
  - Detect devices
- **Receive data from devices**
- **Send data for devices**
- **Communication among agents**
- **Control structure**: sensor, make decisions based on a controller, act, evaluate decisions and adapt
FIoT: Flexible Points

- Different control modules:
  - Neural Network; State Machine

- Different training process for control module:
  - Learning Techniques

- Evaluate the results: how the environment changes have to be evaluated
A NeuroEvolutionary and MultiAgent Approach to Create a Decentralized and Adaptive Car Traffic Control using FIoT

APPLICATION SCENARIO
Application Scenario – Traffic Control

❖ Control Application for a Car Traffic Scenario

❖ Problem Scenario
  ▪ Elements: roads, lanes, cars
  ▪ Elements controlled by agents: only lanes

❖ Decision Control
  ▪ Neural Network

❖ Learning Algorithm
  ▪ Genetic Algorithm
Simulated Environment

<NumberOfCars>: 1000
<MaxCarLane>: 75
<TimeOfSimulation>: 30
Configuring FIoT to Traffic Control Application

(a)

Type: laneNeuralNetwork
<Input>: 4
-microphone1
-microphone2
-previousColorSignal
carRate
<br Output>: 2
colorSignal
signalVoice
<NHiddens>: 2
</end>

(b)

numberOfGeneration: 85
numberOfTests: 1
numOfBestToBeSelected: 10
numOfChildren: 2
numberOfPopulation: 30
maxNumGenes: 12
valueMaxOfGene: 5
rateMutation: 20
fitness: 1
Quickly Background Review

Neural Network

- Memory for associations
- \( y = f(x); \) \( x \): inputs and weights
- \( \text{colorSignal} = f(\text{microphone} \ast W1, \text{carRate} \ast W2, \text{previousSignal} \ast W3) \)
- \( \text{signalVoice} = f(\text{microphone} \ast W4, \text{carRate} \ast W5, \text{previousSignal} \ast W6) \)
- Each weight represents how much each input gives contribution for outputs (the relevance of each one)
- Middle layer: association among inputs
Quickly Background Review

- Genetic Algorithm
  - Unsupervised Learning
  - Each individual:

<table>
<thead>
<tr>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
</tr>
</thead>
</table>

- Fitness: How good is this neural controller with this sequence of weights? (How many cars concluded their route?)
- Get best individuals to generate new individuals (crossover and mutation).
- After 85 generations, use the best one.
Results

- The communication system among lanes, the influence of rate of cars on traffic light decision, nothing was specified before simulation. Norms of traffic, the lanes interactions emerged through evolutionary process.
- Neural Network: black box
Results

Fitness Average – Generations

- Normally, an abrupt change on this graph can indicate the emergence of a new behavior.

- A: car rate makes negative influence. If there is a car, traffic light is put on red
Results

Max Fitness

![Max Fitness - Linear Trend](image-url)
Results

- Best Individual of Generation 4
  - C: Priority is given for Lanes with higher rate of cars
Results

E: Best individual.

- Lanes that don’t have intersection with other lanes adopted the strategy to keep the signal on green

- Most important factor to decide about traffic light is rate of cars, but is not the only one:
  - if traffic light is red and/or the closest lane emits signal zero, the chance of lane to set traffic light on green is higher.
Conclusion

- The main goal of FIoT is to reduce the complexity of development of IoT applications
- Investigate the use of learning techniques to model complex systems based on MAS
- The expected is to easily introduce these concepts on real situation or a most advanced simulated applications
- Contribution of MAS for IoT
References

- Frevo. FFramework for EVOlutionary design. Available on <


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