Sviluppo ed Integrazione di Modelli per Simulazione di Missioni Distribuite

Luca Cistriani

Milano 25/06/2019
Roma 26/06/2019
Topics

1. Introduction
2. The RIACE Synthetic Environment
3. Tools & Processes: a “MATLAB-Simulink centric” toolchain for an Engineering Unit
4. Examples
5. Conclusions
Who is speaking

1. I am a MATLAB User from the mid ‘90s (MATLAB used for the master thesis work in 1999)

2. I used MATLAB & Simulink as standard tools (in conjunction with legacy SW packages developed in FORTRAN, Pascal, etc.) for UAV design for many years.

3. In late 2007 I was tasked to organize an Engineering Unit specifically devoted to develop math models for Training & Simulation … We selected MATLAB & Simulink as the core-suite of our toolchain.
Organization & Business

- ELECTRONICS
- HELICOPTERS
- AIRCRAFT
- AEROSTRUCTURES
- CYBER SECURITY

IELD: 12,240
NEW ORDERS: 15,124
ORDER BACKLOG: 36,118
R&D: 1,440
EMPLOYEES: 46,462

CTO & Engineering

Airborne & Space Systems ITALY

UAS, Training & Simulation

Modeling & Distributed Missions Simulation

Ronchi dei Legionari (GO)
The RIAce Synthetic Environment

What is ... how it is used
Realistic Intelligent Agents for computer environments

RIAce is a Synthetic Environment (SE): a computer-based representation of the real world (including the natural environment, e.g. atmosphere, space, ocean, and terrain), within which any combination of players may interact on a single computer or over a distributed network connected by local and wide area networks and augmented by realistic special effects and accurate behavioral models.

3D Renderings are used to illustrate the functionalities of the Synthetic Environment but the Rendering SW/HW (e.g. the Image Generator) is NOT part of a Synthetic Environment for Distributed Simulation.
Realistic Intelligent Agents for computer environments
Realistic Intelligent Agents for computer environments

Synthetic Environment Server Architecture

- SE Server
  - SE Manager (SSFs)
  - Services
  - Super-Agents
  - Common Models

Agents (Platforms)
- Platforms
  - Typhoon
  - Falco
  - Eagle
  - Böing
  - Helio
  - Tartaruga
NATO Spartan Alliance & Spartan Warrior Exercises
LEONARDO DISTRIBUTED MISSION OPERATIONS

National Hub  
Pratica di Mare

Role Player  
Role Player

Synthetic Environment Server

Gateway  
Bridge  
Radio

Gateway  
Bridge  
Radio

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Radio

FMS  
FMS  
FMS  
FMS  
FMS  
CRC  
AP577 Radar

Tornado  
Galatina

PTT

MALE BattleLab

Amendola

Gioia d.C.

Pratica d. M.

Ramstein

Exercise  
Monitoring & Control

CFBLNET

DIS  
HLA

Warrior  
Preparation Center  
Ramstein

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Company General Use
Goals & Challenges

1. Extremely wide range of applications.

2. Large scale simulations running a great number of agents with different levels of fidelity and complexity in Real-Time.

3. Modelling needs accurate balance between accuracy (complexity and fidelity) and performance (computational resources, execution time).

4. Needs a coordinated effort from a team of specialists with different skills.

5. “Perceived realism of simulation” needs some “preview” of the final application from the early stages of the development.
«Realism» vs Cost and False Myths

In the era of internet it is easy to find reliable information to build your «realistic» math models.

“Among models with roughly equal predictive power, the simplest one is the most desirable.”
Tools & Processes

A “MATLAB-Simulink centric” toolchain for an Engineering Unit
Code generation

Analysis of Requirements

V&V

Development

MODEL

Company General Use
Model Engineer's PCs

- MATLAB
- Simulink
- ...

MATLAB-Simulink Work Stations

- MATLAB
- Simulink

- Aerospace Blockset
- Aerospace Toolbox
- Control System Toolbox
- Embedded Coder
- Fuzzy Logic Toolbox
- MATLAB Coder
- Optimization Toolbox
- Parallel Computing Toolbox
- Simulink 3D Animation
- Simulink Coder
- Simulink Design Optimization
- Simulink Desktop Real-Time
- Stateflow
- System Identification Toolbox
- ...

CFD

- MGAERO
- OMNI3D

3D

- X-Plane
- Plane Maker

Company General Use
Enabling Factors and Features

1. Most of the applications use **formatted text files for I/O** … this makes exchange of data easier.

2. MATLAB & Simulink allow the implementation of “libraries” of tools and components for reuse in math models and applications.

3. Intrinsic **modularity** of MATLAB & Simulink exploited to develop complex models from **building blocks** (referenced models).

4. Storage of **data templates** (e.g. data buses) allows multiple applications to maintain their **interfaces aligned**.
Example: Simulation of Ballistic Munitions

Modeling of trajectory and terminal effects
\[ \nu = \frac{V_0}{1 + K_0 \cdot V_0 \cdot ToF} \]

\[ s = \frac{1}{K_0} \cdot \log \left[ \left( ToF + \frac{1}{K_0 \cdot V_0} \right) \cdot K_0 \cdot V_0 \right] \]
M1A2 Medium Fidelity Tank Model

Bounding Sphere

Vulnerable component (120mm gun)

Component bounding volumes

Bounding Volume

Armor geometry & RHA thickness
Perforation/Ricochet

Ricocheting trajectory

Shotline origin
(on bounding sphere)

Perforation trajectory
(multiple armor impact points)
Example: Simulation of Air-to-Air Missiles

Geometric Modelling for CFD, Dynamics, Seeker and Guidance Model
Conclusions

Achievements and further ideas
Achievements and further ideas

1. Cannot say how much we improved our performance … we simply cannot imagine our work without MATLAB & Simulink.

2. The fully integrated toolchain allows large scale projects to be developed in reasonable times but is also highly effective for prototyping and demonstration purposes.

3. After several years of usage and improvement, the building blocks have an high reliability (high number of hours and low bugs rate).

4. Looking forward, we aim to extend the portfolio of toolboxes to better exploit the availability of ready-to-use resources from MathWorks.
Point Of Contact:

- Luca Cistriani
- Modelling & Distributed Missions Simulations
- LEONARDO Electronics Division
- Via Mario Stoppani, 21, 34077, Ronchi dei Legionari
- luca.cistriani@leonardocompany.com
- 0481 478 415
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