SPARTACUS

POSITIONING SOLUTIONS FOR CRITICAL ASSET TRACKING AND CRISIS MANAGEMENT

LUCA VITTUARI*, MATTEO ZANZI**, ANTONIO GHETTI**

*DICAM, UNIVERSITY OF BOLOGNA, ITALY;
**DEI - UNIVERSITY OF BOLOGNA, FORLÌ, ITALY.
Outline:

- Introduction to SPARTACUS
- Tracking applications:
  - Transport (TR)
  - Relief Goods Distribution (RGD)
  - First Responders tracking & guidance
- Two steps positioning approach (TR and RGD):
  - Low level
  - Upper level
- Numerical simulations
- Preliminary First Responders field test
- SPARTACUS answer & innovation
Introduction to SPARTACUS

Partners

Large Enterprises:
• D’Appolonia S.p.A.
• Romanian Railway Authority
• TriaGnoSys GmbH

Small to Medium Enterprises:
• DMAT Consulting KG
• AnsuR Technologies
• GlobalGPS BH
• SBG systems SAS

Research and Academic:
• University of Pavia
• University of Bologna
• Newcastle University
• Institute Mihajlo Pupin
• Johanniter-Unfall-Hilfe e.V.

CRITICAL TRANSPORT ASSETS TRACKING

TIIMISS Applications
Goods tracking & Driver assistance
Delivery report & warehouse management

Tracking Unit
Multiple transport assets tracking

Communication Unit
Transportable unit
Local wireless access point & Satellite backhaul link

FIRST RESPONDERS TRACKING & GUIDANCE

FLARE Applications
Navigation and guidance (indoor and outdoor)

ASIGN Applications
Optimized observation collection (audio/video/text/pictures)

Tracking Unit
First responders tracking

Communication Unit
Portable unit
Local wireless access point & Satellite backhaul link

SPARTACUS Mapping Portal

Fleet Management
Decision Support Tool
Location Based Services

Project Technical Coordinator: Clemente Fuggini, D’Appolonia S.p.A.
clemente.fuggini@dappolonia.it

Università di Trieste
19th February 2016
Tracking applications

Three main fields of application

1. **Transport**: tracking freight trains and containers (i.e. dangerous transports);

2. **Relief Goods Distribution**: tracking of trucks and containers (i.e. during civil protection missions);

3. **First Responders**: outdoor & indoor tracking of pedestrian first responders (i.e. management of firebrigade and sanitary personell teams).

Stakeholders requirement for positioning precision:

- ±3m in open sky conditions;
- ±10m after 60s GNSS outage.
Main HW devices shared by all the applications

- **STrackU:** Spartacus Tracking Unit (GNSS/INS Sensor&data)
- **SCoIU/SFU:** Spartacus Collecting Unit or Smart Field Unit (data fusion)
- **SComU:** Spartacus Communication Unit (radio link)
Transport

- **RED** = STrackU
- **GREEN** = SColU
Relief Goods Distribution

- **RED** = STrackU
- **GREEN** = SColU
First Responders

- **RED** = STrackU
- **GREEN** = SFU
- Performs Low-Level positioning functions for containers, wagons and locomotive
- All information are stored internally in a LIFO stack together with ID
- Temperature, humidity sensors and limit switch are foreseen as future option
SCoIU HW

- Performs the Upper-Level positioning functions for containers and wagons
- All information are stored internally in a LIFO stack together with ID
- Gives a real time monitoring data to the SComU and the train driver
Extended Kalman Filter implementation
SCoIU SW Upper-Level algorithms

- Lower level positioning STrackU_1
- Lower level positioning STrackU_2
- Lower level positioning STrackU_n

position, velocity
unit 1

position, velocity
unit 2

SCoIU/SFU Upper level Positioning functions

Kinematics constraints

Refined Position Unit 1

Refined Position Unit n
SCoLU data fusion filter model

EKF filter kinematic constraints:
- relative distance
- relative velocity
- aligned velocity and heading
- radius of curvature of railway

\[
\begin{align*}
\dot{N}_i &= V \cos(\chi_i) \\
\dot{E}_i &= V \sin(\chi_i) \\
\dot{V} &= a_{il} \\
\dot{\chi}_i &= \Omega_i \\
\dot{R}_{ji} &= 0 \\
\dot{\sigma}_{ji} &= \frac{2V \sin(\chi_i - \sigma_{ji})}{R_{ji}}
\end{align*}
\]
SCoLu data fusion filter model

EKF filter kinematic constraints:
- relative distance
- relative velocity

\[
\begin{align*}
\dot{N}_T &= V_T \cos(\chi_T) \\
\dot{E}_T &= V_T \sin(\chi_T) \\
\dot{\psi} &= \frac{V_T}{L} \sin(\chi_T - \psi) \\
\dot{L} &= 0 \\
\dot{d} &= 0
\end{align*}
\]
STrackU tests

- Field Test for Transport Application
SCoIU simulation implemented

Simulation parameters:

- constant speed = 20 [m/s]
- curvature radius = r = 700 [m]
- the simulation begins without GNSS satellite signal coverage
- the simulation continues without GNSS satellite signal coverage for 120 seconds

Motion profile for Transport application
SCoLU simulations results

60' of GNSS signal outage accuracy

Before 5m
After 5m

Before 100m
After 5m

UNIT

LOCOMOTIVE

CONTAINER or WAGON

UNIT

60' of GNSS signal outage accuracy

Before 5m
After 5m

Before 100m
After 5m
STrackU tests

- Field Test for RGD Application
SCoIU simulations implemented

Simulation parameters:

- constant speed = 15[m/s]
- the simulation begins without GNSS satellite signal coverage
- the simulation continues without GNSS satellite signal coverage for t=120[s]

Motion profile for RGD application
SCoLU simulations results

UNIT

TRUCK

TRAILER

60' of GNSS signal outage accuracy

Before 10m

After 6m

Before 100m

After 6m
First Responders application

The evolution of STRACKU_PERSON FR tests
FR STrackU path tests

Field Test for FR Application
The horizontal error after 60s of dead reckoning (point 60) is under 5m
For all three targeted applications, SPARTACUS offers a system able to:

- Determine the position independently from external infrastructure (STrackU = GNSS + INS)
- Have a low/medium cost for dead reckoning capabilities according to the application (Transport, RGD, FR)
- Black box information capabilities for each module (STrackU/SCoLU/SFU)
- An infrastructure less Broadband Global Area Network radio interface
- Have a power consumption, weight and size dependent on the application (Transport, RGD, FR)
Thank you for your attention

luca.vittuari@unibo.it