

Human Factors Evaluation in IoT Software Design and Implementation

Giovanna Broccia



giovanna.broccia@isti.cnr.it



T-LADIES KICK-OFF



PISA



6/7 JULY 2022

Hello, I'm Giovanna Broccia



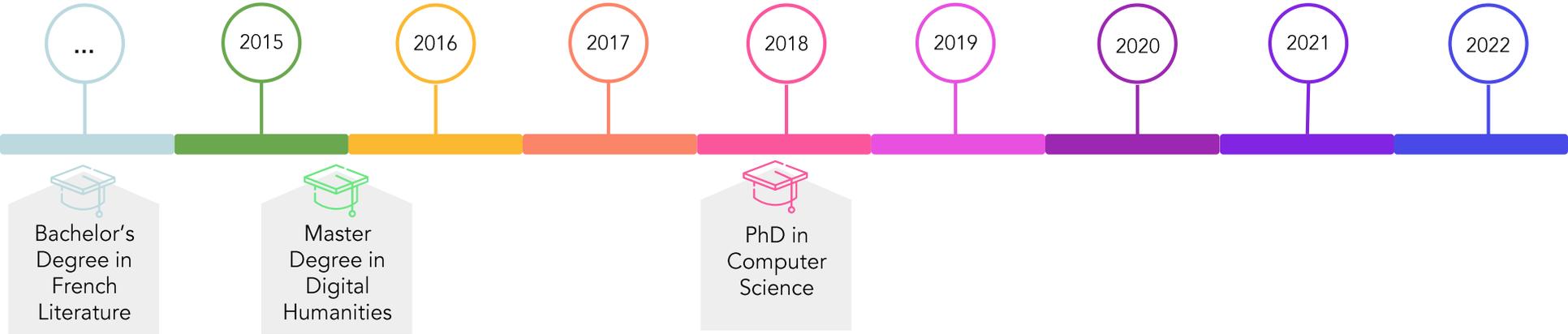
A Domain Specific Language for Game Modelling and Analysis

Supervisor: Prof. Paolo Milazzo (University of Pisa)

This research broadly extends a previous work which deploys **PRISM Model Checker** for modelling and analysing board games. Specifically, we devised and developed a **Domain Specific Language (DSL)** in order to **improve the expressiveness, effectiveness and conciseness of the original modelling**. This novel DSL further enhance the previous work by allowing to the user to model a wider set of features of the board game.



Hello, I'm **Giovanna Broccia**



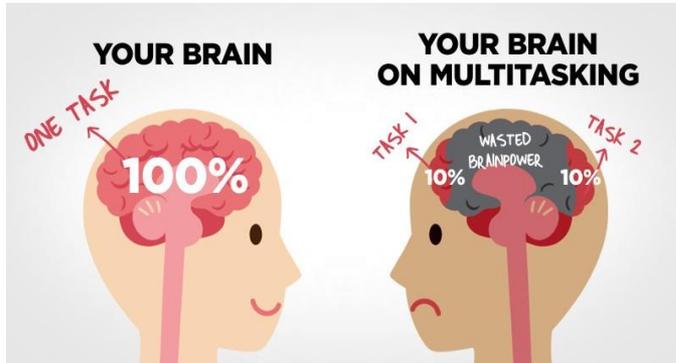
Hello, I'm Giovanna Broccia



PhD in
Computer
Science

A Formal Framework for Modelling and Analysing Safety-Critical Human Multitasking
Supervisor: Prof. Paolo Milazzo, University of Pisa

Probabilistic Transition System, whose transition relation is defined by a **set of inference rules**. Each rule models a different cognitive process involved in multitasking



MEMORY OVERLOAD

Forgetting useful information for the completion of the task

COGNITIVE OVERLOAD

Ignoring a task in a crucial moment or for too long

Hello, I'm **Giovanna Broccia**



PhD in
Computer
Science

A Formal Framework for Modelling and Analysing Safety-Critical Human Multitasking
Supervisor: Prof. Paolo Milazzo, University of Pisa

Probabilistic Transition System, whose transition relation is defined by a **set of inference rules**. Each rule models a different cognitive process involved in multitasking

Real-time Maude Executable Framework

analyse multitasking through simulation and reachability analysis

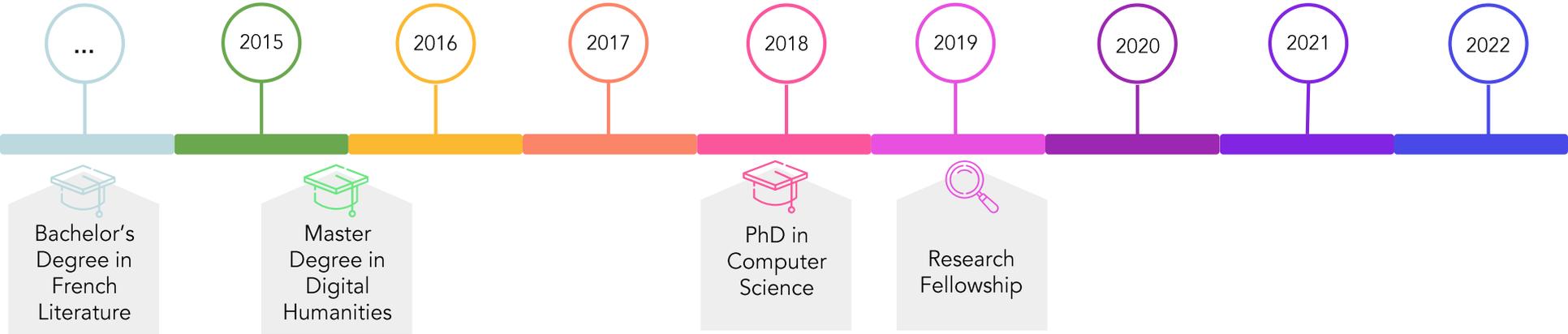
G. Broccia, P. Milazzo, P. C. Ölveczky
Formal modeling and analysis of safety-critical human multitasking.

In *Innovations in Systems and Software Engineering* 15 (3), 169-190

1. Using GPS navigator system while driving
2. Setting multiple infusion pumps simultaneously
3. Typical concurrent tasks of an air traffic control operator



Hello, I'm **Giovanna Broccia**



Hello, I'm **Giovanna Broccia**



Research
Fellowship



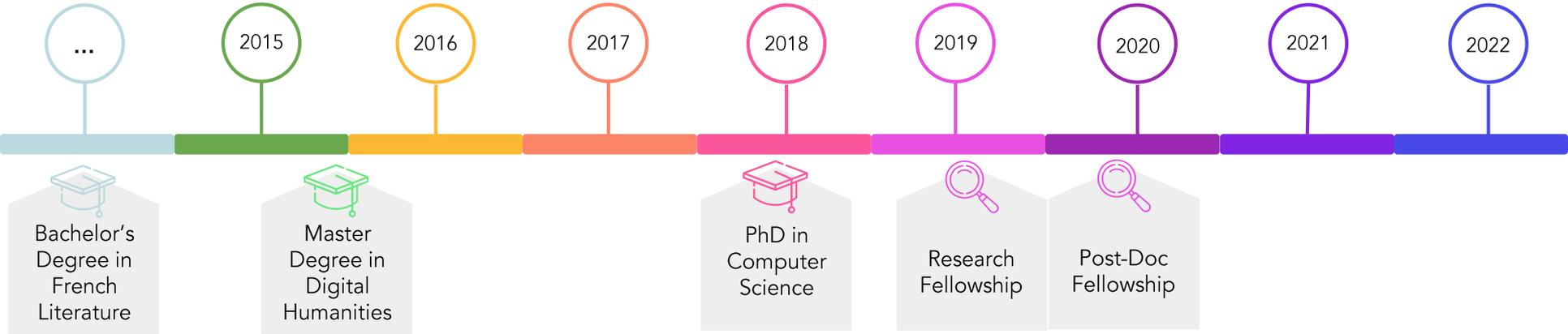
Human Interfaces In Information Systems Laboratory

HCI aspects

1. Web Accessibility Evaluation
2. Interface Usability Evaluation

G. Broccia, M. Manca, F. Paternò, F. Pulina
**Flexible automatic support for web
accessibility validation**
*In Proceeding of the ACT on Human-
Computer Interaction 4 (EICS)*

Hello, I'm **Giovanna Broccia**



Hello, I'm **Giovanna Broccia**



Post-Doc
Fellowship



Formal Methods and Tools Laboratory



Work areas

1. Application of spatial model checking to (medical) image analysis
2. Design, implementation and evaluation of a GUI for the spatial model checker VoxLogicA
3. Comprehensability study on Attack-Defense Tree notation

Hello, I'm Giovanna Broccia



Post-Doc
Fellowship

1. Application of spatial model checking to (medical) image analysis

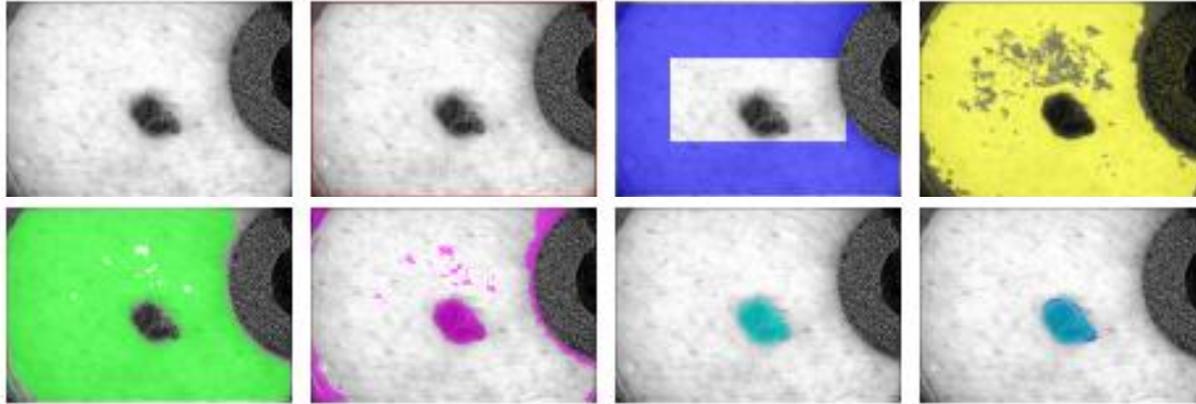


Hello, I'm Giovanna Broccia



Post-Doc
Fellowship

1. Application of spatial model checking to (medical) image analysis



G. Belmonte, G. Broccia, V. Ciancia, D. Latella, M. Massink
Feasibility of Spatial Model Checking for Nevus Segmentation
In *2021 IEEE/ACM 9th International Conference on Formal Methods
in Software Engineering (FormalISE)*

Hello, I'm Giovanna Broccia



Post-Doc
Fellowship

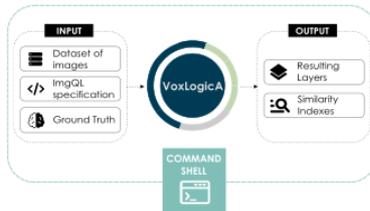
2. Design, implementation and evaluation of a GUI for the spatial model checker VoxLogicA

TOWARDS A GUI FOR DECLARATIVE MEDICAL IMAGE ANALYSIS

G. Broccia, V. Ciancia, D. Latella, M. Massink

MOTIVATION

The spatial model checker **VoxLogicA** has been successfully applied to medical image segmentation [1].



- COMMAND • hinders its usability
- SHELL • limits a broader uptake
- USAGE • requires higher cognitive effort

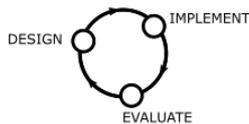
1. G. Belmonte, V. Ciancia, D. Latella, M. Massink
VoxLogicA: a spatial model checker for declarative image analysis.
In International Conference on Tools and Algorithms for the Construction and Analysis of Systems

DESIGN

USER-CENTRED GUI



GUI evaluation in a
iterative design cycle



EVALUATION

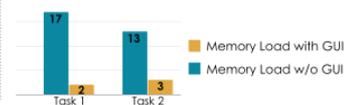
RQ1. What is the effect of layers selection on task performance?



RQ2. Is the relation between the layers and the specification clear to users?



RQ3. How does GUI vs. command line layer selection affect memory load?



G. Broccia, V. Ciancia,
D. Latella, M. Massink
Toward a GUI for
Declarative Medical
Image Analysis:
Cognitive and
Memory Load Issues
In *International
Conference on
Human-Computer
Interaction (HCII 2022)*,
103-111

Hello, I'm Giovanna Broccia

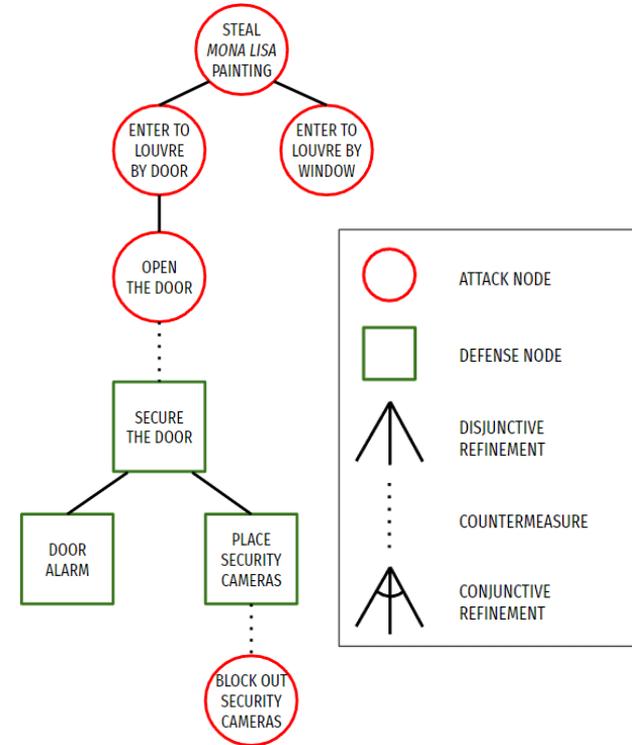


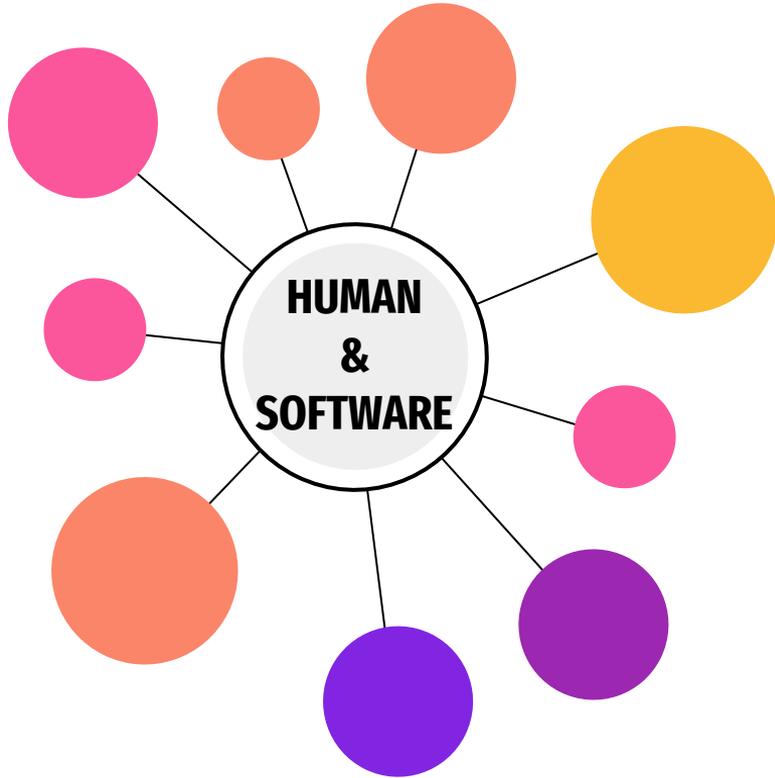
Post-Doc
Fellowship

3. Comprehensability study on Attack-Defense Tree (ADT) notation

To effectively assess the security of the system, ADTs might serve as one *easily understandable* human-readable notation. To verify this hypothesis, user studies are necessary.

- RQ1.** How **understandable** is the semantics of the notation?
- RQ2.** How much **transferable** is the knowledge of the notation?
- RQ3.** How much is an **instantiated ADT** comprehensible by users?
- RQ4.** To what extent is the notation **appreciated** by users?



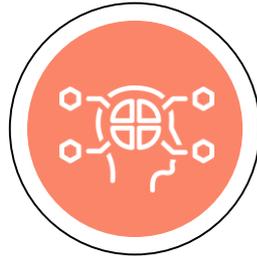


Multidisciplinary

Human Factors Evaluation



Usability
evaluation



Comprehensibility
evaluation



Cognitive
Evaluation

Human Factors Evaluation



**Usability
evaluation**

- **Usability** (ISO 9241-11) is the extent to which a product can be used by specified users to achieve specified goals **with effectiveness, efficiency, and satisfaction** in a specified context of use.
- Usability is one of the **most widely used concept in the software engineering** field and defines the software **system's demand and use**, it is also an inherent measurable property of all interactive digital technologies.
- **Usability Evaluation Methods (UEM)** are procedures composed by a set of well-defined activities that are used to evaluate the system's usability. There are 3 main UEM categories: user testing, inspection, and inquire.

Human Factors Evaluation



Usability
evaluation

- VOICE USER INTERFACE

B.Suhm.

Towards best practices for speech user interface design.

- AUGMENTED/VIRTUAL REALITY INTERFACE

A. Dünser and M. Billinghamurst

Evaluating augmented reality systems.

- BODY-BASED INTERACTION

F. Pulina and F. Paternò

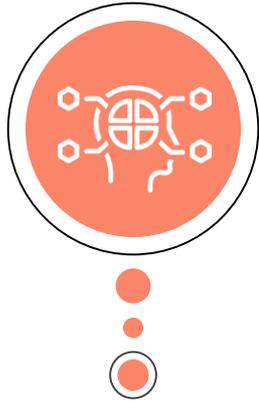
Supporting cross-device interactions with gestures between personal and public devices.

- IOT SYSTEMS INTERACTION

J. P. Dias, F. Couto, A. C. R. Paiva, H. S. Ferreira

A Brief Overview of Existing Tools for Testing the Internet-of-Things

Human Factors Evaluation



Comprehensibility
evaluation

- How much a system, a notation, a language is *comprehensible*
- The more a system/notation/language is comprehensible by users, the more it is used
- IoT risk assessment through comprehensible system conceptual model

Tyson Macaulay
RIoT Control: Understanding and Managing Risks
and the Internet of Things

Human Factors Evaluation

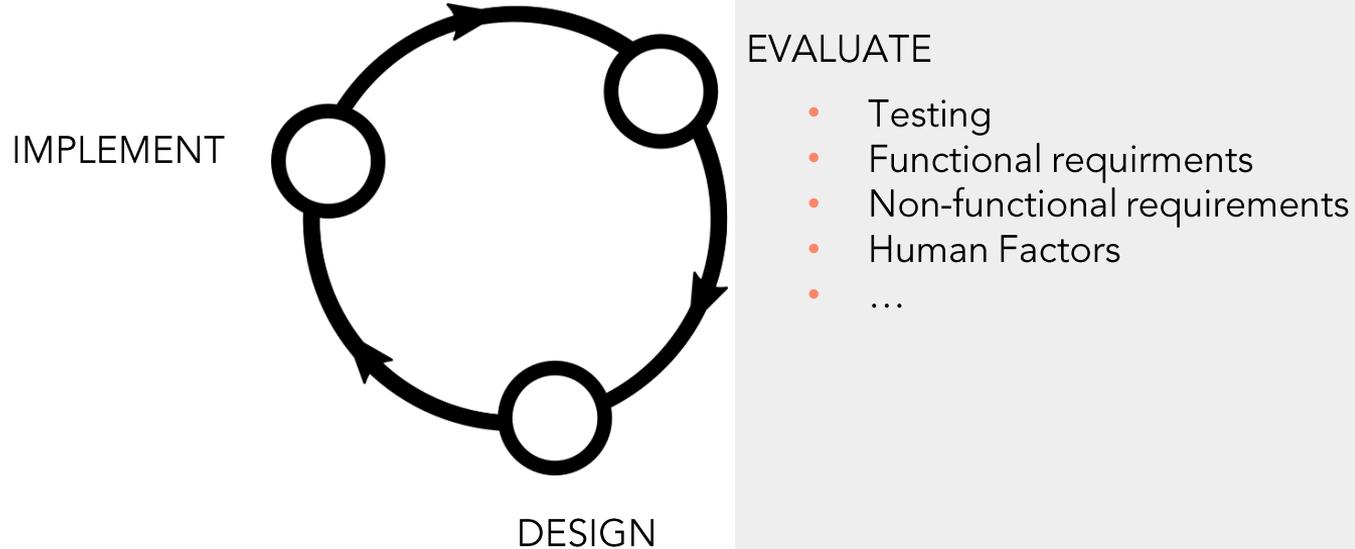


**Cognitive
Evaluation**

- New kind of evaluation
- **Cognitive effort** refers to how many pieces of information a user need to **keep in his working memory and process** during the task execution, and how much these pieces of information **require direct attention** to be kept in memory and processed
- **New kind of interaction methods** need to be cognitively *easy*:
 - Few information to be kept in memory
 - Task simplified and divided into small basic task
 - A clear explanation of the system
 - Visual feedbacks for each user activity on the system

T4: Application to IoT SW development

ITERATIVE DEVELOPMENT CYCLE



T2: Interaction for interoperability and adaptation

M. H. ter Beek, V. Ciancia, D. Latella, M. Massink and G. O. Spagnolo

Spatial Model Checking for Smart Stations: Research Challenges.

In *Formal Methods for Industrial Critical Systems: 26th International Conference, FMICS 2021, Paris, France, August 24–26, 2021, Proceedings* (pp. 39-47).

Abstract.

(...) We envisioned how to use the spatial model checker VoxLogicA to explore the areas that users can visit in a station area and to characterise them with respect to their illumination conditions.

We also ideate statistical spatio-temporal model checking of the **design of energy-saving protocols**, exploiting the modelling of user preferences.

Finally, we discuss the idea of **quantifying the impact of design changes**, based on the logs of smart stations, to identify and measure the incidence of undesired events (e.g. non-illuminated platforms where a train is passing by) before and after each change.

**Thank you,
Questions?**



giovanna.broccia@isti.cnr.it

