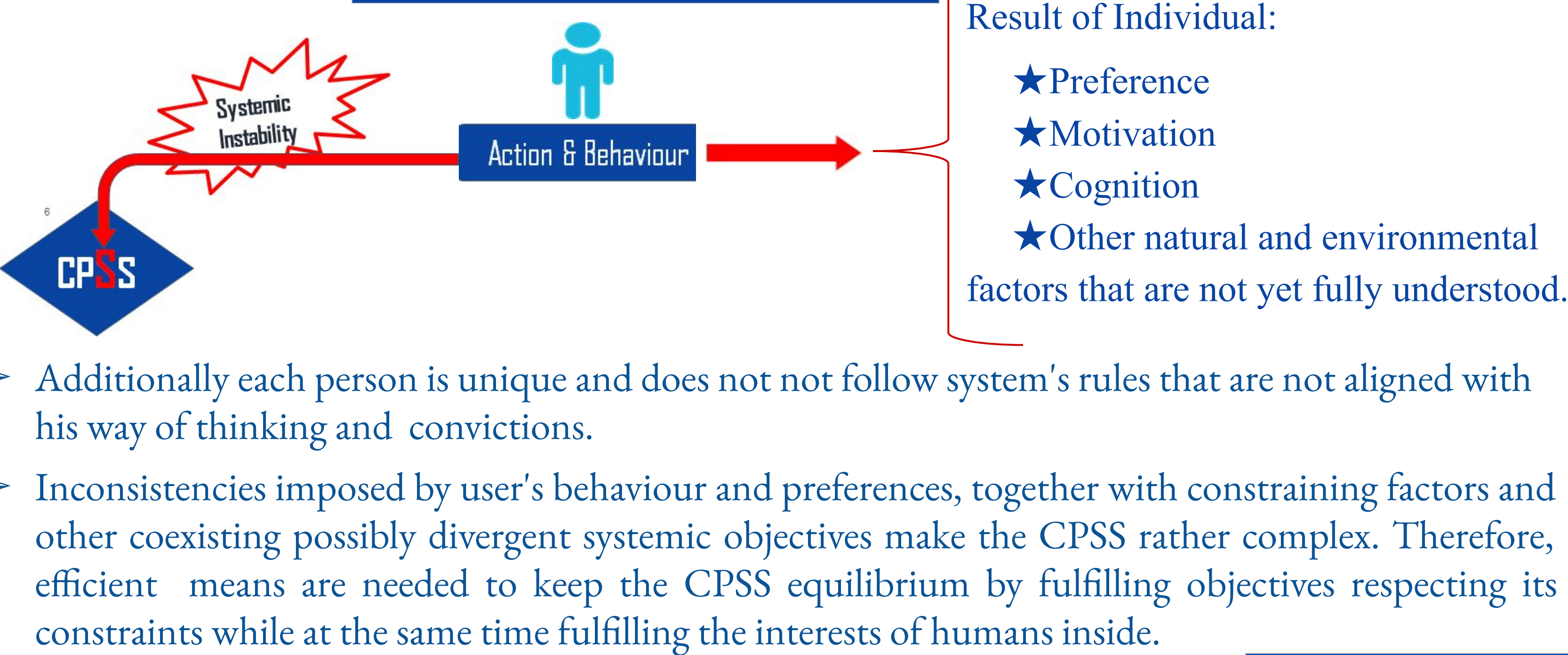




Cyber-Physical-Social Systems (CPSS)

- CPSS can be understood as an **environment, or system**, where **humans and machines** evolve in both the **physical** and the **virtual world**, interacting all together.
- From a systemic perspective a CPSS is defined as a system that emerges through the interaction of cyber, physical and social components. [3]

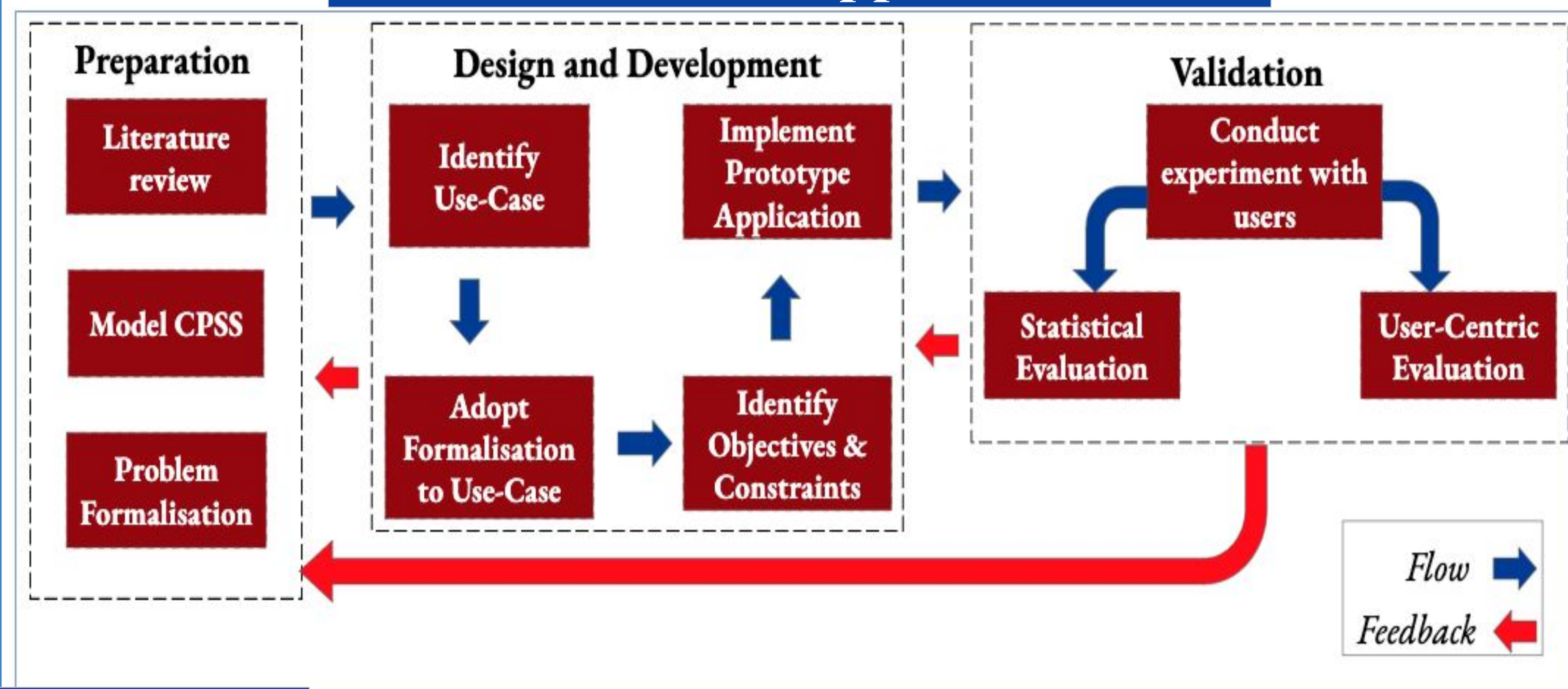
Problem Setting



Personalisation

- "Personalisation is the task of tailoring a service or a product in a way that it fits to specific individuals' preferences, cognition, needs or capabilities under a given context."
- (Goy et al, 2015)

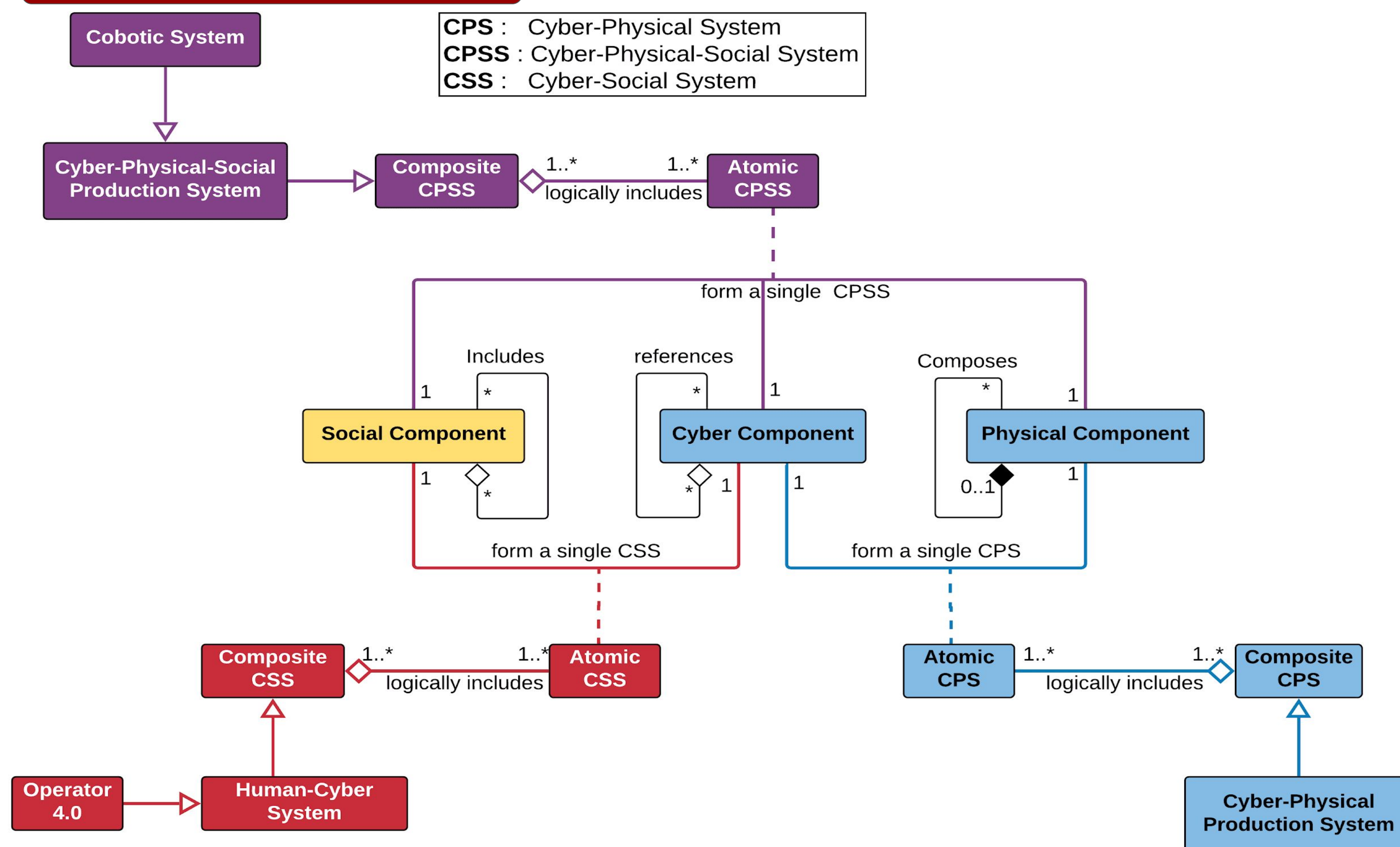
Research Approach



Preliminary Results

SOTA analysis (A systematic literature review)

A meta-model of CPSS



Problem formalisation: Personalisation in CPSS

- The problem of Personalisation in CPSS for a user u is formalised as a function of the user u , the Cyber-physical-social system $CPSS$, the social system S in which he evolves, the IT application implementing personalized services a and the global context CX .

$$Perso^u_{cpss} = f(u, cpss, s, a, cx) \quad (1)$$

Identify Illustrative Use cases

1. Personalisation in exhibition areas

- The $CPSS$ → (Museum \cup Objects \cup POIs) mu
- The social system S → Crowd of other people (Visitors) cr

$$Perso^u_{cpss} = f(u, cpss, s, a, cx) \quad (1) \rightarrow Perso^u_{exhib} = f(u, mu, cr, a, cx) \quad (2)$$

- Exhibition areas are typical CPSS environments where visitors and sensor enabled smart devices cohabit a physical space of interaction.
- Introducing a personalisation service in such environments requires making best possible compromise among multiple coexisting objectives subject to constraints.

- Multiple Objectives
 - Several Constraints
- **Constrained Multi-Objective Optimisation Problem**

2. Personalisation in Cobotics

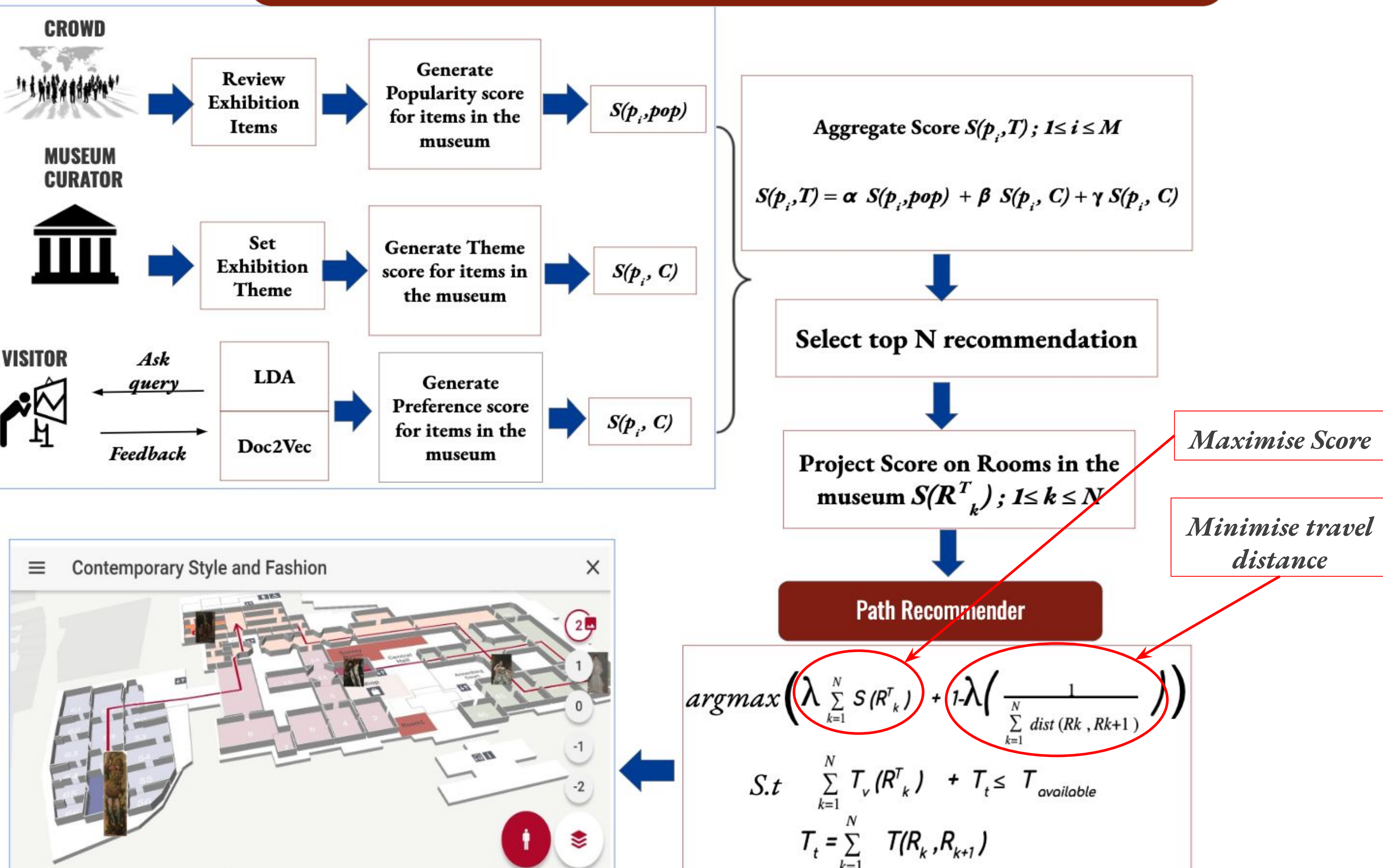
- The $CPSS$ → (factory \cup Objects)
- The social system S → Other Users (Workers) w
- The application a → Cobot (cb)

$$Perso^u_{cpss} = f(u, cpss, s, a, cx) \quad (1) \rightarrow Perso^u_{cob} = f(u, fa, cb, cx) \quad (3)$$

- Cobotic systems can also be seen as typical CPSS environments where Human workers and Cobots work in collaboration.
- The aim of personalisation in Cobotics is :
 - To design Production environment that can adapt to the workers.
 - To enable Cobots to recognise human interaction responses (Cognitive, emotional and behavioural) and react accordingly.
 - To design a means so that Cobots can learn important human values and needs (Social aspects) through interaction.

Ongoing Work...

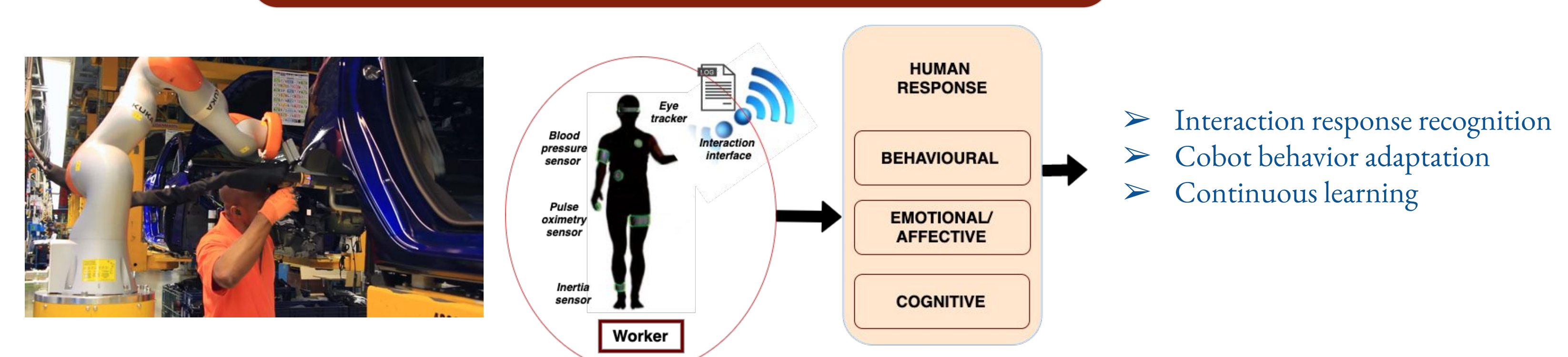
Personalised guidance application for The National gallery, London



User preference modelling (Algorithms)	Frameworks	Evaluation	Validation
<ul style="list-style-type: none"> Latent Dirichlet allocation (LDA) Doc2Vec (Shallow neural network) 	<ul style="list-style-type: none"> Tensorflow PyTorch Gensim Scikit-learn 	<ul style="list-style-type: none"> MILP Optimisation PULP Gurobi 	<ul style="list-style-type: none"> Statistical Perplexity Accuracy User-Centric evaluation framework (Pu et al. 2011)

Future Work

Prototype Personalised application in Cobot environment



Perspectives

- Personalisation for building more efficient, stable and smarter CPSS.
- The perspective contributes both to the fields of CPSS, and **personalisation/User Modelling/Recommender Systems** where application to the physical world have gained momentum.
- Brings opportunities to contribute to new Crowd Management approaches, matching the objectives of both the environment and the individual users.

Publications

- Y. Naudet, B.A Yilma and H.Panetto.: Personalisation in Cyber Physical and Social Systems: the Case of Recommendations in Cultural Heritage Spaces, on the 13th International Workshop on Semantic and Social Media Adaptation and Personalisation (SMAP 2018)
- Bereket A. Yilma, Y. Naudet and H.Panetto.: Introduction to Personalisation in Cyber-Physical-Social Systems, on the 13th OTM/IFAC/IFIP International Workshop on Enterprise Integration, Interoperability and Networking (EI2N 2018).
- Bereket A. Yilma, Y. Naudet and H.Panetto.: A Meta-Model of Cyber-Physical-Social System: The CPSS Paradigm to Support Human-Machine Collaboration in Industry 4.0, on 20th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2019.