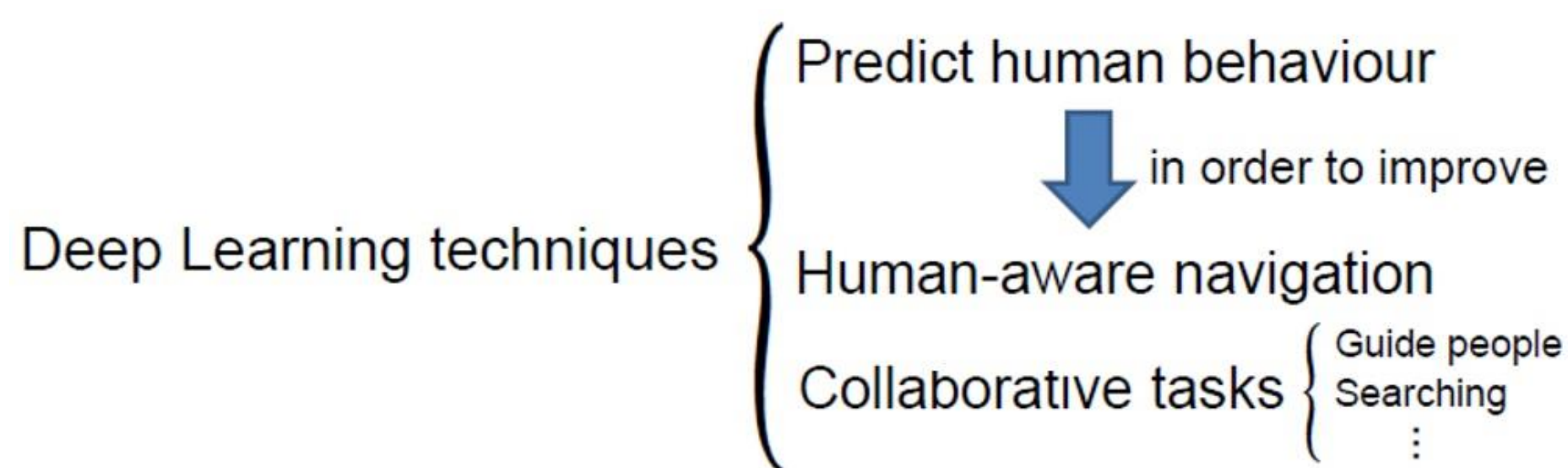# Robot Navigation Issues and Human-Robot Collaborative Search using Deep Learning Methods

**Author:** **Óscar Gil Viyuela**
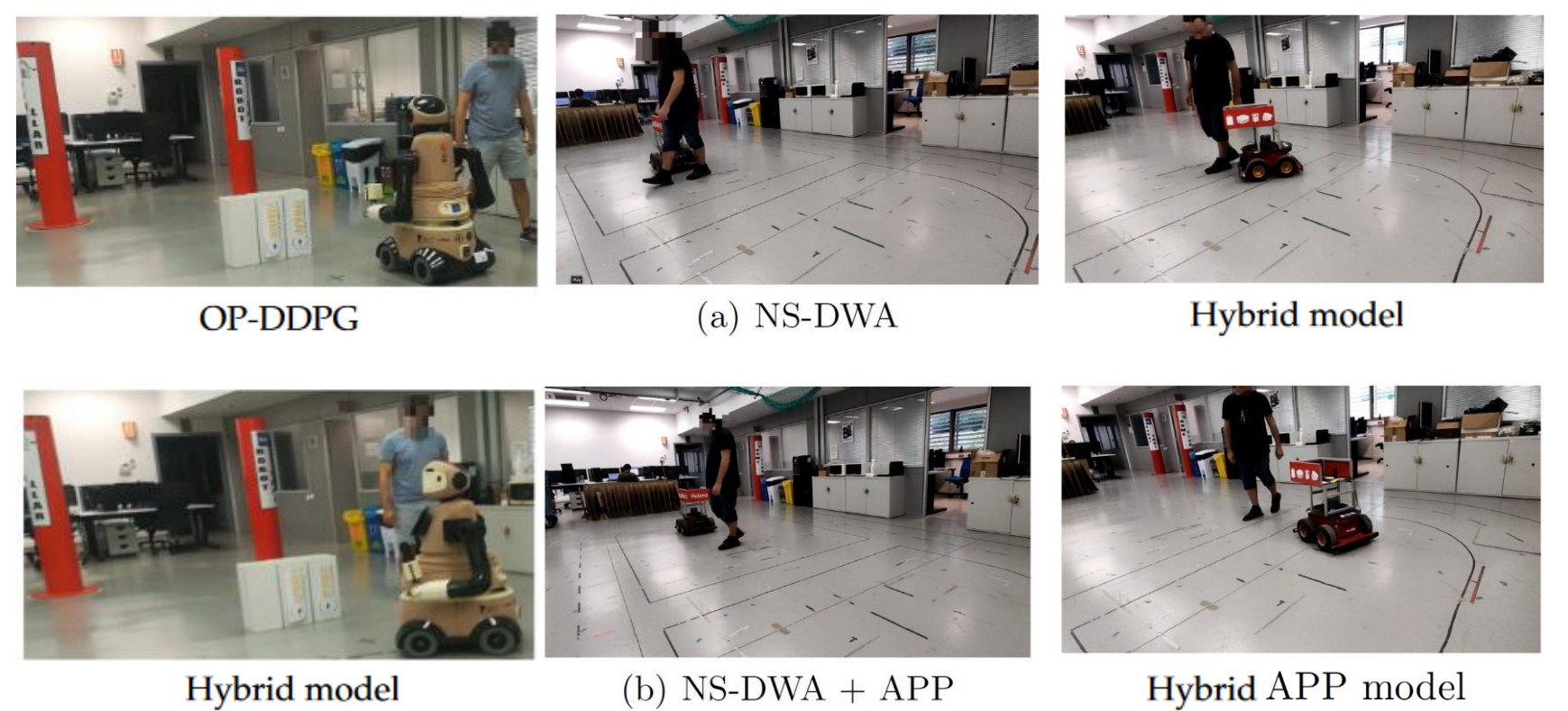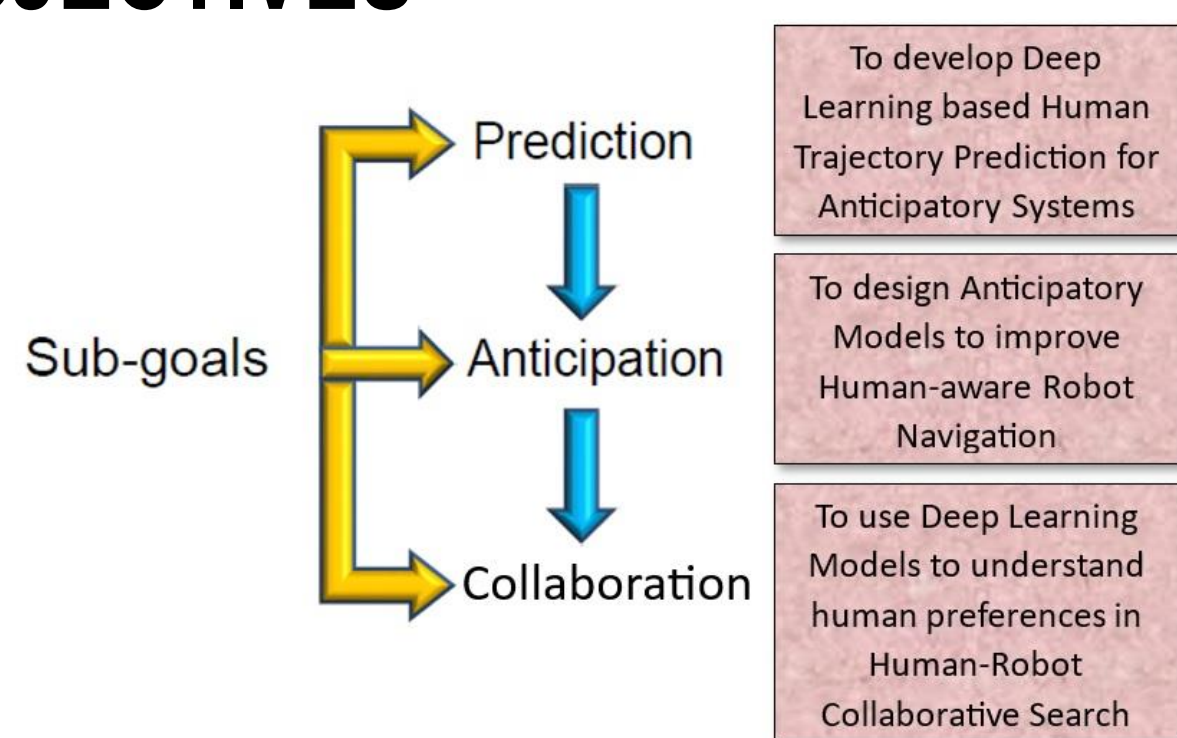
**Supervisor(s):** **Alberto Sanfeliu Cortés**

## 1. MOTIVATION

- Deep Learning is useful to predict and model human behavior which can help in Robot Navigation and Human-Robot Collaboration

Deep Learning techniques { Predict human behaviour → in order to improve → Human-aware navigation. Collaborative tasks { Guide people, Searching ⋮

## 2. OBJECTIVES

Sub-goals → Prediction → Anticipation → Collaboration

- To develop Deep Learning based Human Trajectory Prediction for Anticipatory Systems
- To design Anticipatory Models to improve Human-aware Robot Navigation
- To use Deep Learning Models to understand human preferences in Human-Robot Collaborative Search

## 3. HUMAN TRAJECTORY PREDICTION MODEL [4]

- **Conclusion**: Using the Social Force Model as environment information and the possible goal information improves the accuracy of the model.

## 4. ROBOT NAVIGATION MODELS

- Deep Q-Learning and Social Force Model [1]:

CONCLUSION

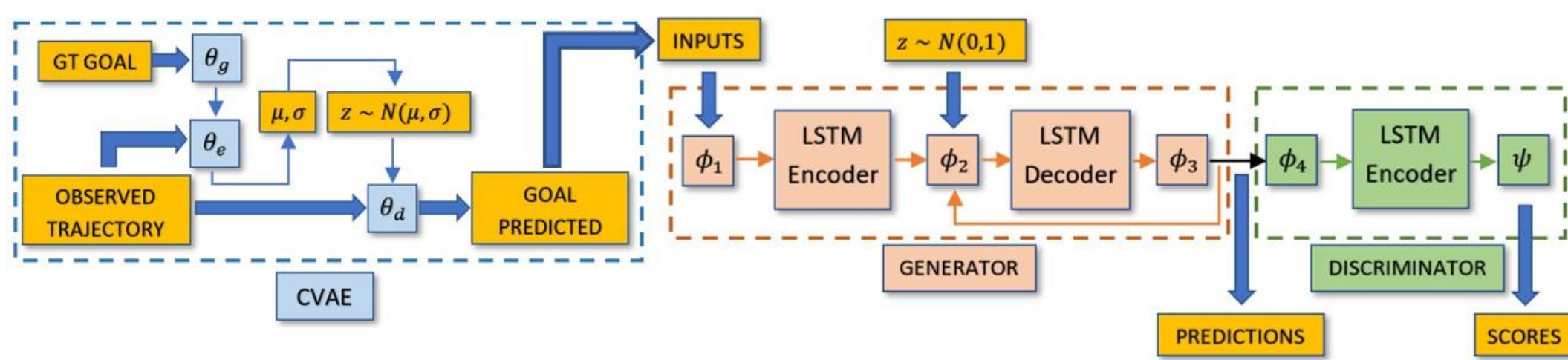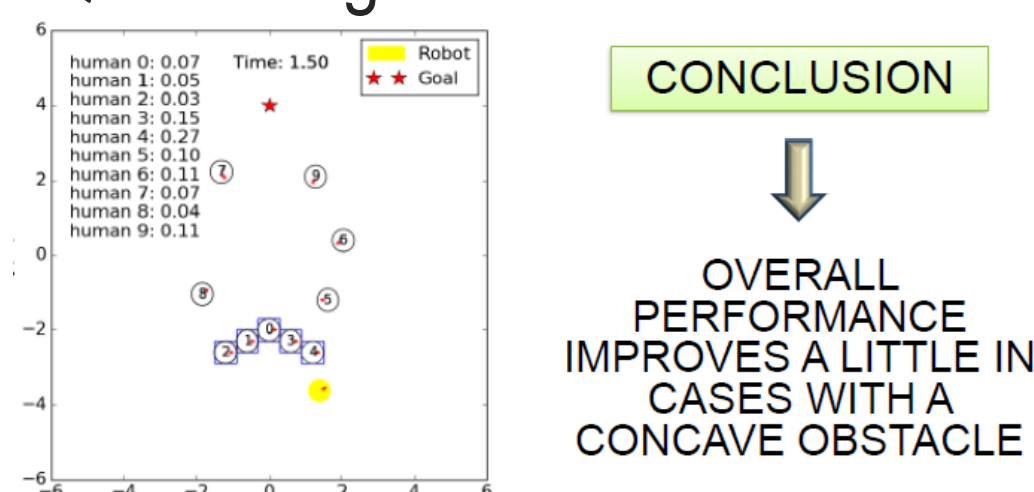OVERALL PERFORMANCE IMPROVES A LITTLE IN CASES WITH A CONCAVE OBSTACLE

- A hybrid navigation model using Deep Deterministic Policy Gradients (OP-DDPG) and Social Force Model [2] combined with an anticipative model [3]:

OP-DDPG  (a) NS-DWA  Hybrid model

Hybrid model  (b) NS-DWA + APP  Hybrid APP model

**CONCLUSIONS**:
- The Social Force Model improves the learned policy ability to predict a possible collision and avoid it.
- The anticipation model improves the human robot encounters when it is added to the ROS navigation stack or the Hybrid Model.

## 5. HUMAN-ROBOT COLLABORATIVE SEARCH MODEL

- A CNN to predict preferent areas to search and preferences of search participants are combined in a new Human-Robot Collaborative Search System.
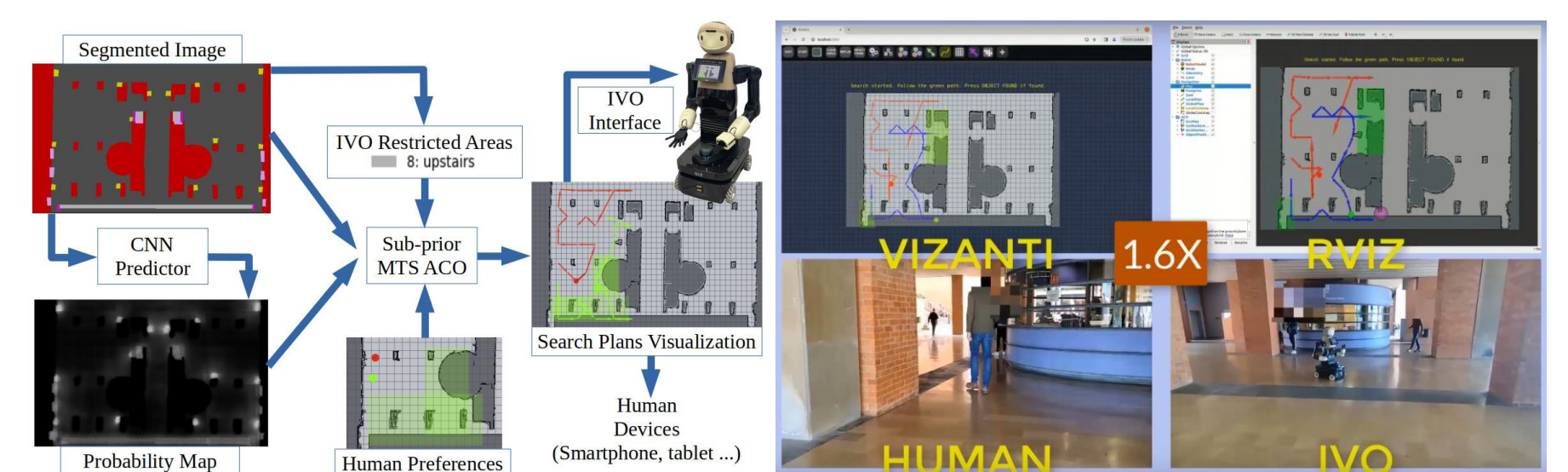
**CONCLUSIONS**:
- The Ant Colony Optimization (ACO) search system is preferred by users when their preferences are taken into account.
- The Probability Map predictor can obtain low error in results with small datasets

## 6. FUTURE WORK

- Apply other Deep Learning models and adaptation systems in Robot Navigation.
- Consider real-time replanning in the searching task.

**References**

[1] O. Gil and A. Sanfeliu. Effects of a social force model reward in robot navigation based on deep reinforcement learning, **4th Iberian Robotics Conference**, 2019, Porto, Portugal, Vol 1093 of Advances in Intelligent Systems and Computing, pp. 213-224, Springer.

[2] O. Gil, A. Garrell Zulueta and A. Sanfeliu. Social robot navigation tasks: Combining machine learning techniques and Social Force Model. **Sensors**, 21(7087): 23, 2021.

[3] O. Gil and A. Sanfeliu. Robot navigation anticipative strategies in deep reinforcement motion planning. **5th Iberian Robotics Conference**, 2022, Zaragoza, Spain, Vol 590 of Lecture Notes in Networks and Systems, pp. 67-78, Springer.

[4] O. Gil and A. Sanfeliu. Human motion trajectory prediction using the Social Force Model for real-time and low computational cost applications, **6th Iberian Robotics Conference**, 2023, Coimbra, Portugal, Vol 976 of Lecture Notes in Networks and Systems, pp. 1-12, Springer.