RoboCup MSL
Technical challenge 2021

UNIVERSITÉ DE TOULON

RoboCup

RoboCup MSL - Technical challenge 2021
Playing with humans

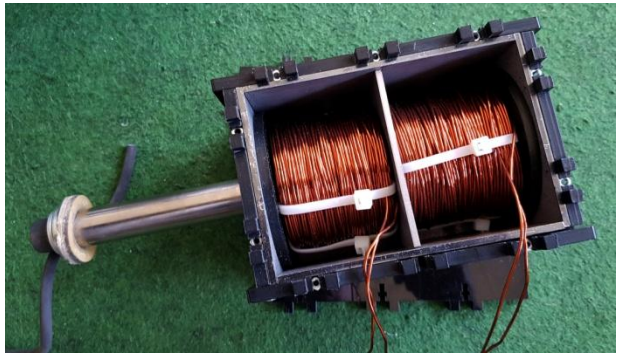
- Playing with humans : the (near) future of RoboCup MSL
  - A major step on the road to 2050

RoboCup MSL - Technical challenge 2021
Playing with humans

- Playing with humans raises major challenges
  - Playing without digital communications
    - Except for the referee
  - Improving drastically embedded perception
    - No more shared perception
    - Requires Robots/humans/landmarks identification and localisation
    - Maintaining or reducing hardware cost
  - Improving robot skills
    - Require to be competitive with humans

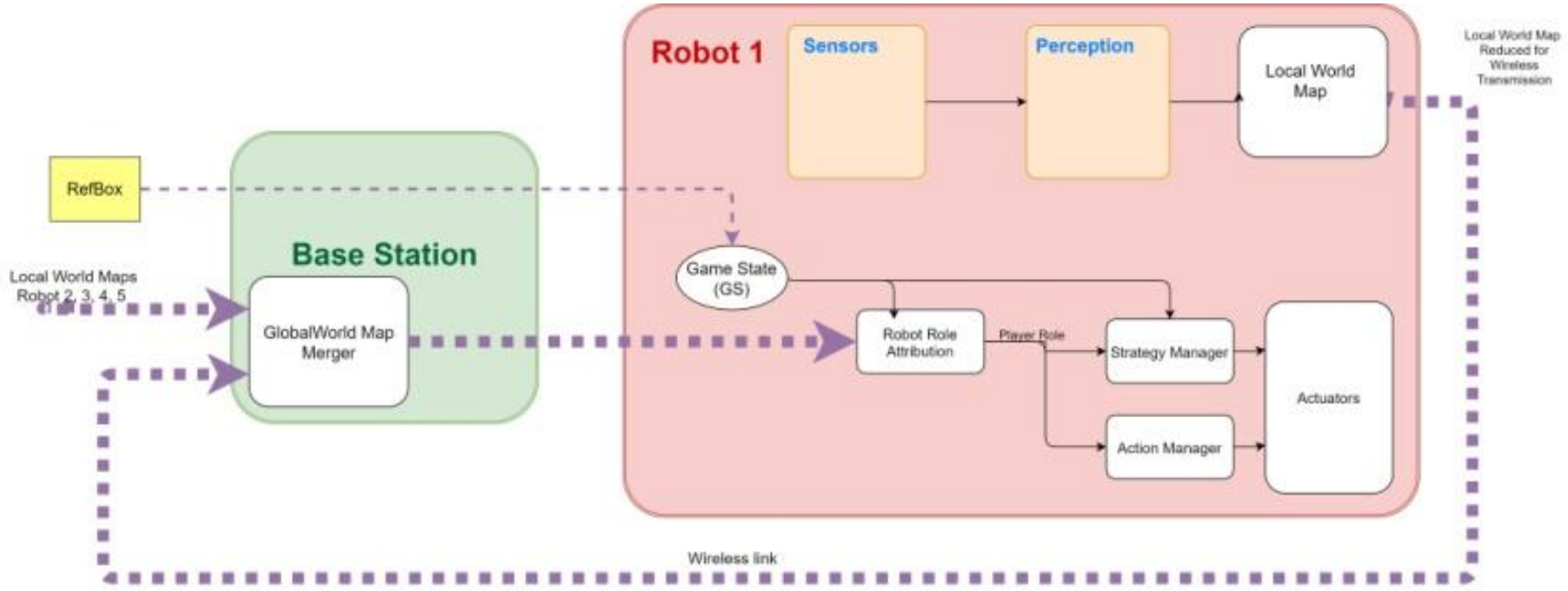
RoboCup MSL - Technical challenge 2021
Playing with humans

- RCT advances in playing with humans
  - Playing without wireless communications
    - Presented in this technical challenge
    - Almost fully implemented by RCT
  - Improving embedded perception
    - Presented tomorrow in scientific challenge !
    - Implemented in RCT robots
  - Improving robot skills
    - A new optimized coil gun for improving kicking strength
      - Presented in this technical challenge
      - Implemented in RCT robots



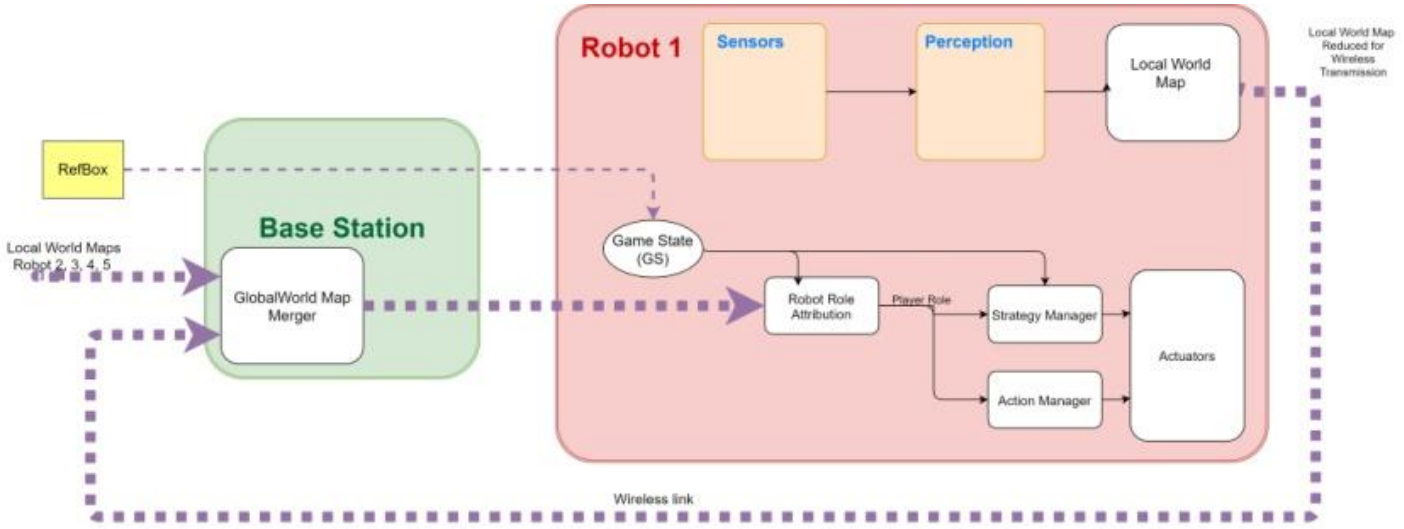
RoboCup MSL - Technical challenge 2021
I - Playing without digital communication

- A starting point : team communications using Multicast
  - Local world maps sent from robots
  - Global world map sent from base station



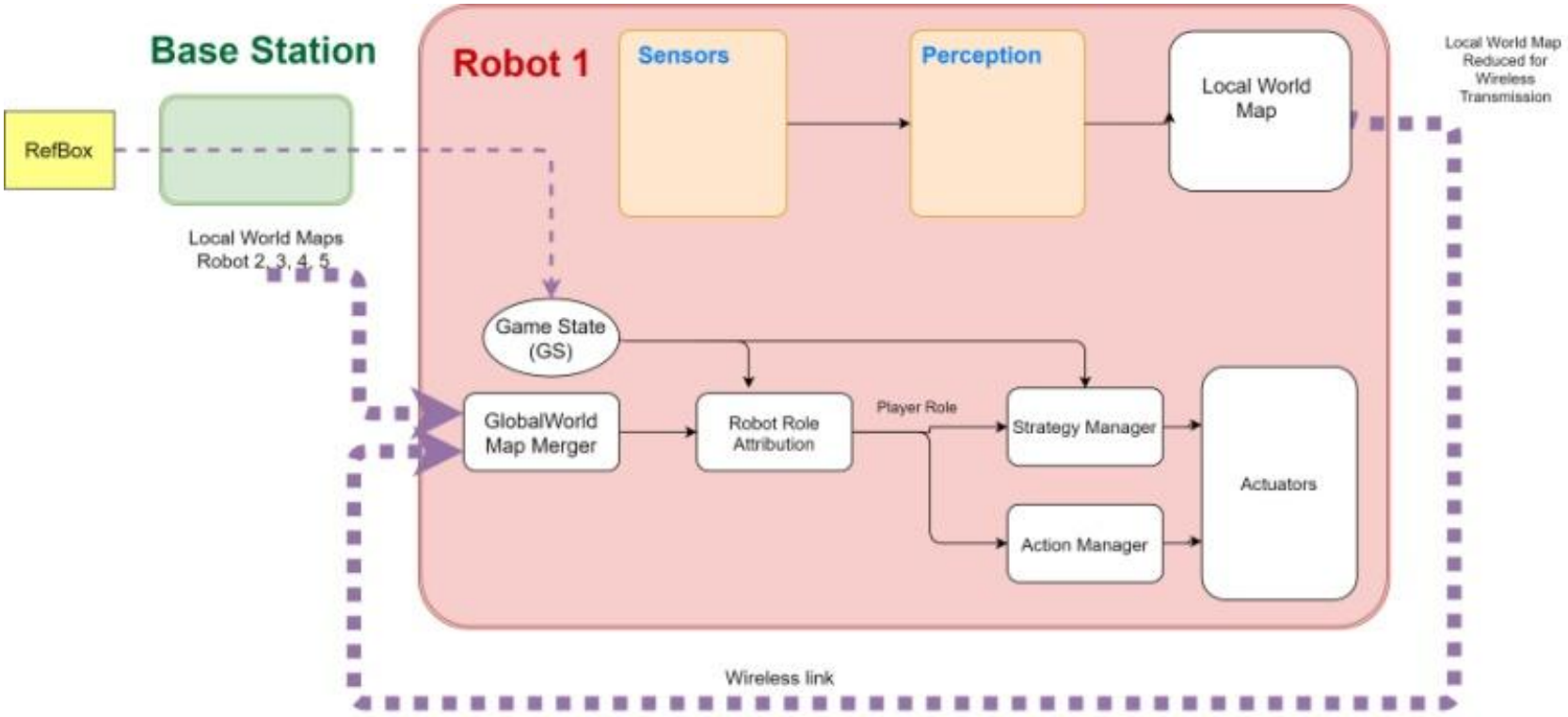
RoboCup MSL - Technical challenge 2021
I - Playing without digital communication

- A starting point : team communications using Multicast
  - Pro :
    - Perception sharing : multiple points of view
    - Map merges on base station : reduces embedded computations
  - Cons :
    - Important latency for transmissions
    - **Far from human behaviour**
      - Everyone tells its position



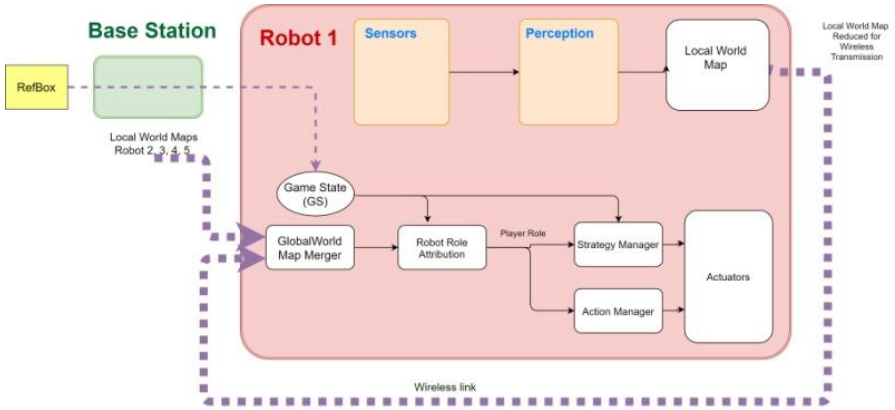
RoboCup MSL - Technical challenge 2021
I - Playing without digital communications

- **Removing base station** : a first step toward communication removal
  - Local world map from each robot sent to all robots (multicast)
  - Every robot generate global world map.



RoboCup MSL - Technical challenge 2021
I - Playing without digital communications

- **Removing base station** : a first step toward communication removal
  - Pro :
    - Perception sharing : multiple point of view
    - No transmission of Global World Map : reduces latency
    - Deterministic if multicast sharing of local world works properly.
      - Everyone as the same information
  - Cons :
    - Increased computional effort on robots.
    - **Far from human behaviour**
      - Everyone tells its position
  - Base station still forward RefBox info.
  - Operational in RCT robot



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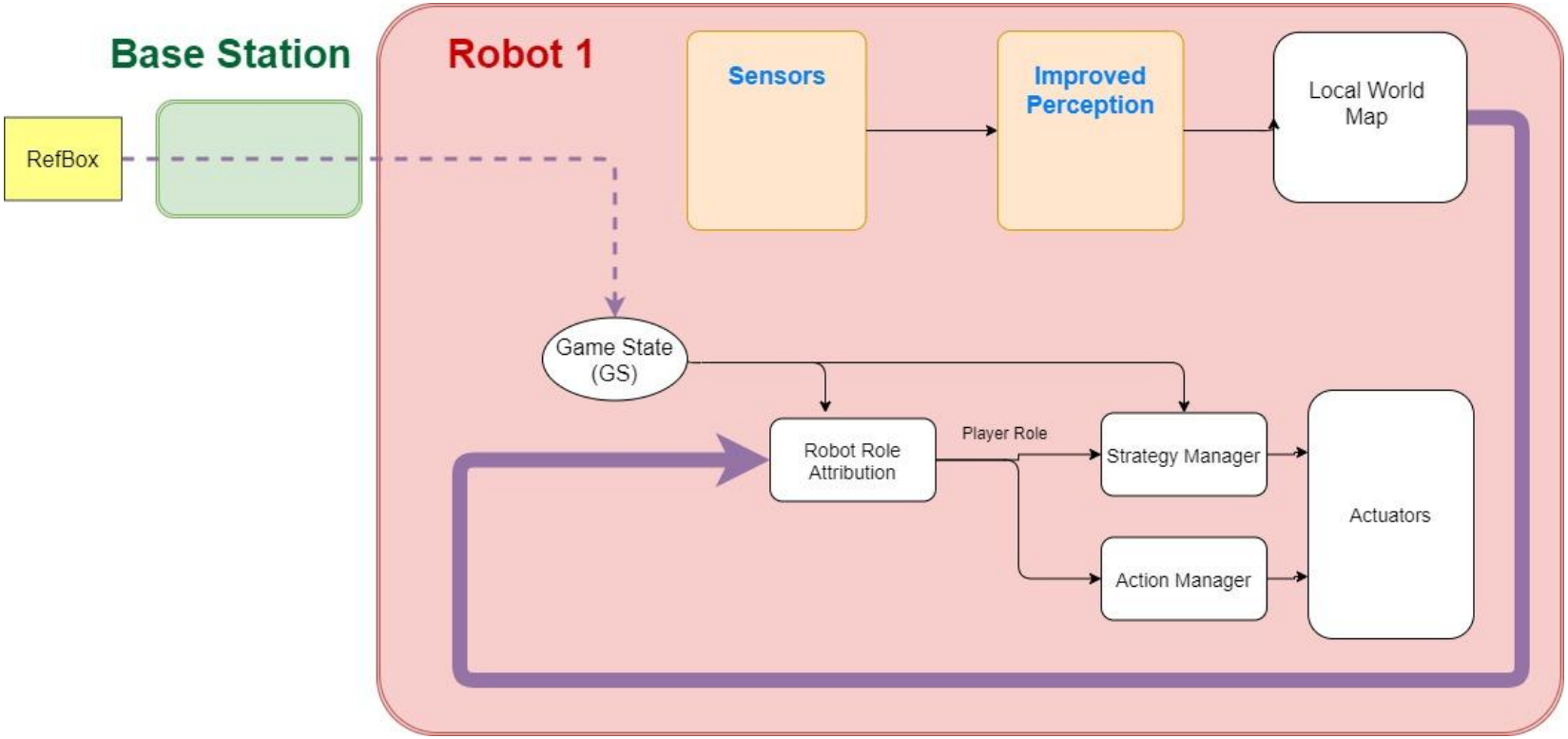
Playing with humans

- What is really necessary for a human player ?
  - Teammates / opponents / goal position / approximate location : YES
  - **Is it strictly necessary to have communication for that ? NO**
    - Except for referee actions

RoboCup MSL - Technical challenge 2021
I - Playing without digital communication

- A major change implemented in 2021 : **removing digital communications for being closer to humans**



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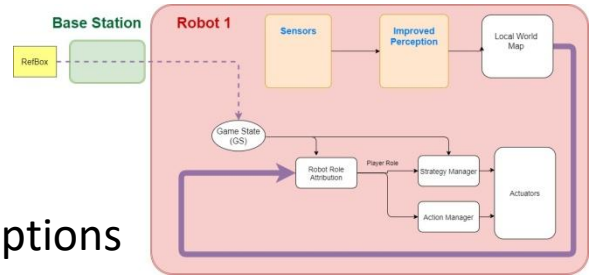
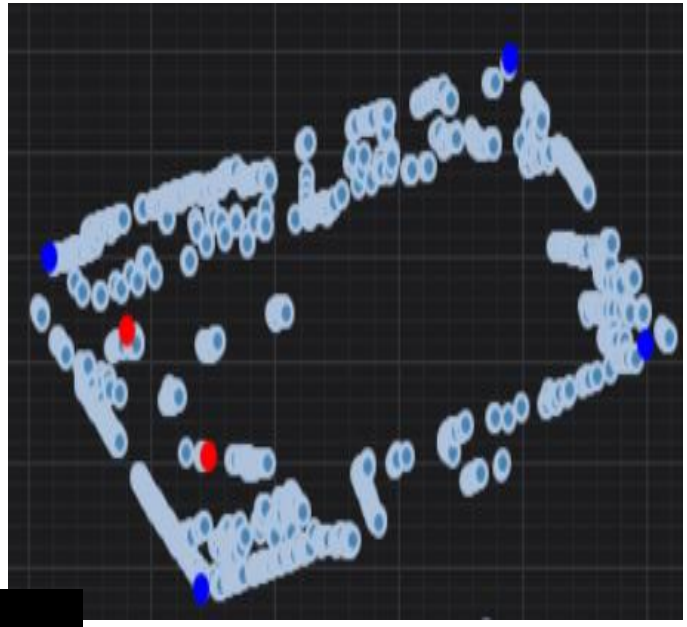


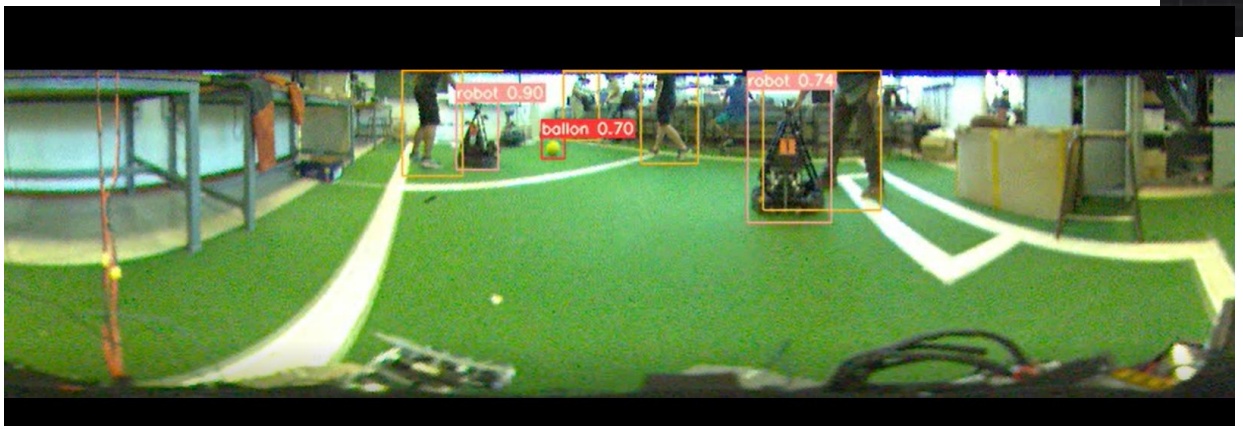
  - Pro : an important key for playing with humans
    - **Close to human behaviour**
      - Robots don't advertise their locations and perceptions
      - Robots and humans are equivalent algorithmically.
  - Cons : require important changes in perception
    - No information sharing :
      - No redundancy : require a more reliable perception
      - Strategy algorithms have to consider that every teammate doesn't have the same information. More difficult to assign roles.

  - **A fantastic field for research !**

RoboCup MSL - Technical challenge 2021
II – Improving embedded perception

- Removing digital communication => improving perception
  - Teammates / opponent identification from a single point of view.
    - Robots or humans
  - Reliable positioning
    - Finding landmarks even in difficult scenes
      - Field corners / Goal posts
    - Finding teammates and opponents positions
  - Using complementary sensors and processing
    - Camera / Lidar / IMU

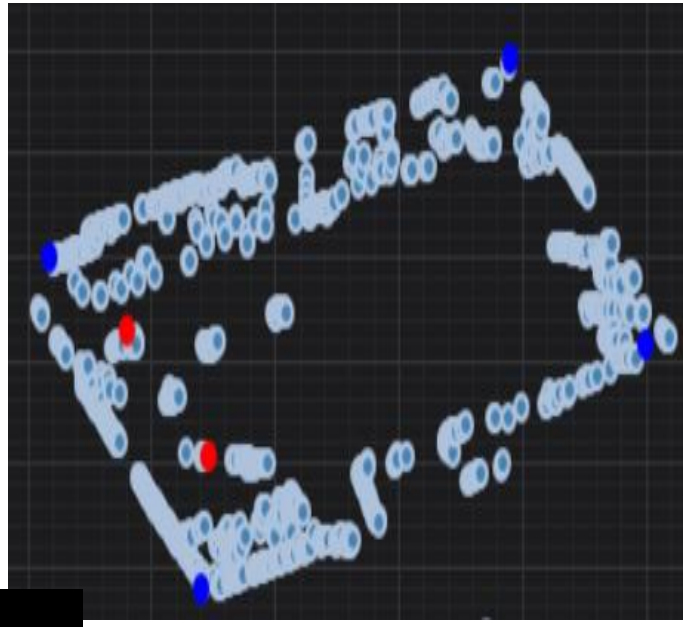


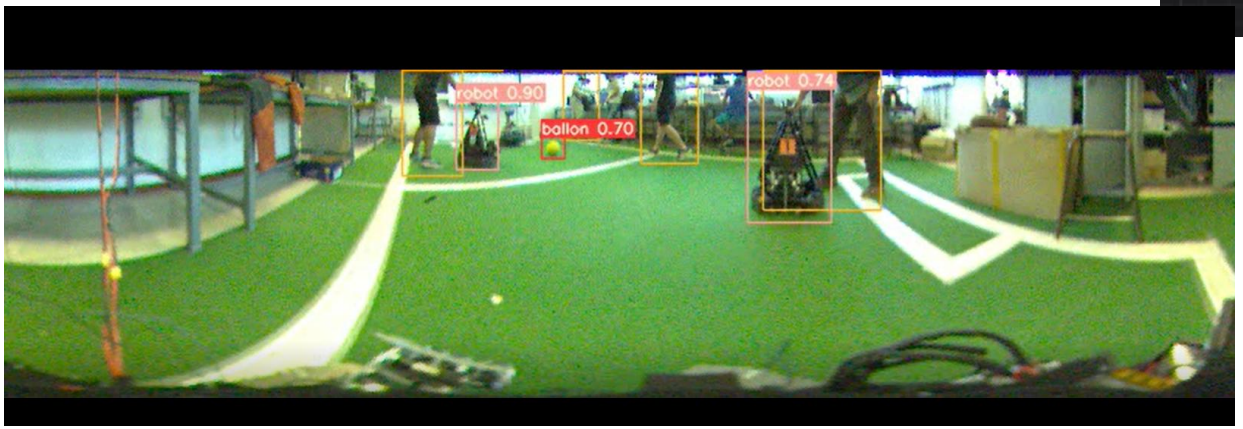


RoboCup MSL - Technical challenge 2021
II – Improving embedded perception

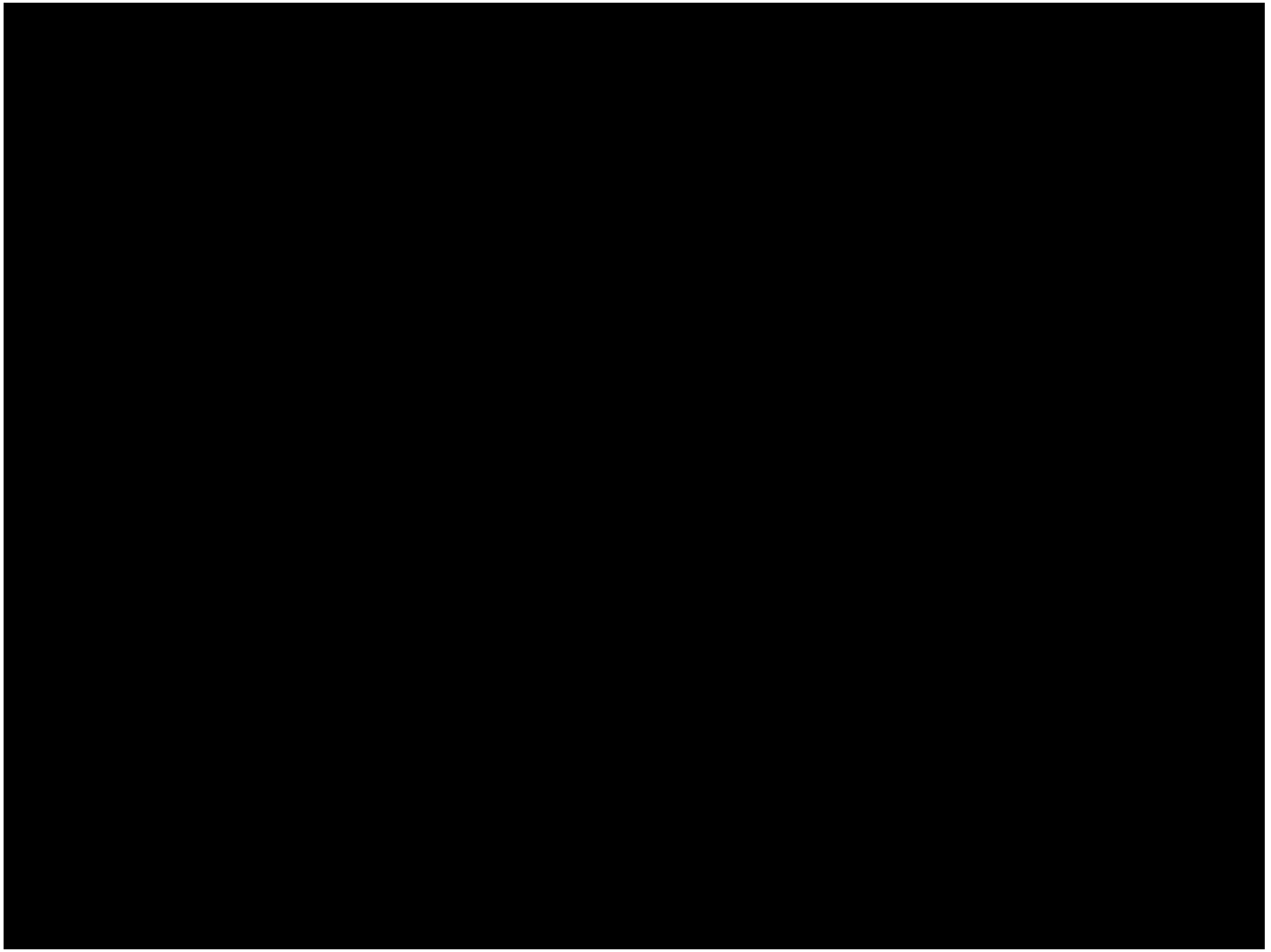
- Removing digital communication => improving perception

Fully presented tomorrow in scientific challenge !



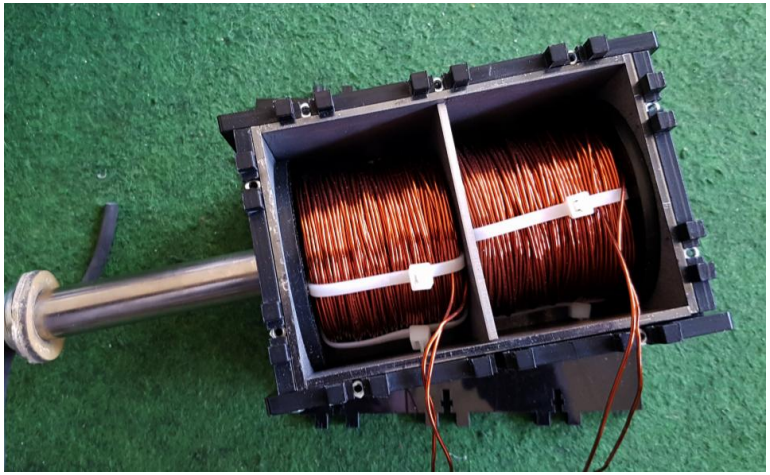


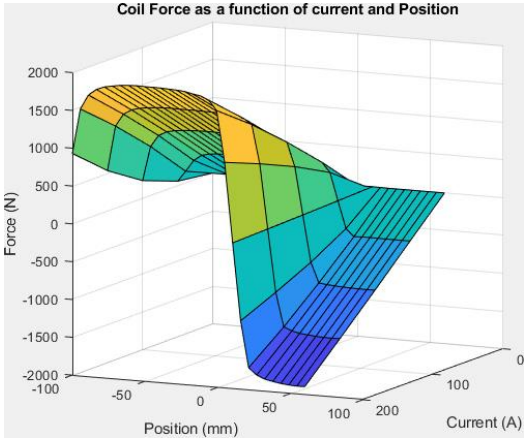
RoboCup MSL - Technical challenge 2021
III – Improving robot skills



RoboCup MSL - Technical challenge 2021
III – Improving robot skills

- A new optimised coil gun
  - Hypothesis :
    - Keeping the same amount of copper
    - Keeping the same capacitance value
  - Simulated using finite elements (FEMM 4.2)
  - Optimized with Matlab
    - Best nb of coils : 2
    - Pulses delay : 7 ms
    - Initial plunger position : 9 cm





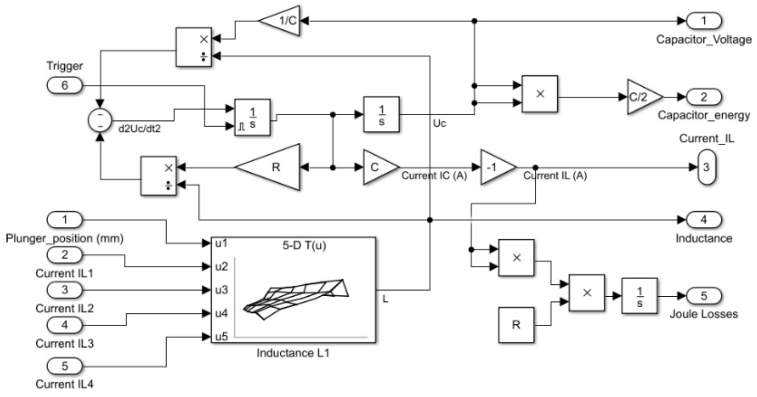
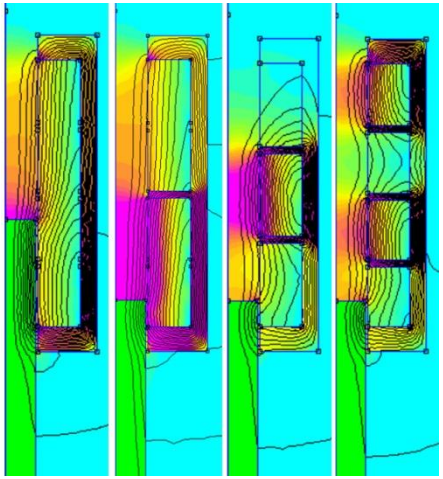


Figure 20. Electrical model of the first coil of an electromagnetic launcher with 4 coils.



RoboCup MSL - Technical challenge 2021
III – Improving robot skills

- Theoretical and experimental results :
  - Ball speed :
    - Theoretically up to 60km/h – measured at more than 50 km/h
    - Max shooting distance (first rebound) : 28m – measured 25m.
    - Reproductible for other teams (published paper and shared design).
  - Better than existing solutions
    - Ratio energy/volume :
      - 10 times better than human leg
      - 5 times better than rotating launcher

Table 5. Ball launchers comparison including optimized launcher.

Launcher	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	Weight (kg)	Ball Speed ($m \cdot s^{-1}$)	Ball Energy (J)	$\frac{Energy}{Volume}$ ($J \cdot dm^{-3}$)
Soccer player leg	160	20	80	133×10^3	20	36	290	**2.18**
Rotating inertial launcher	25	65	25	40×10^3	25	29	190	**4.75**
Robot arm [9]	240	240	30	1360×10^3	50	21	100	**0.07**
Reluctance coil gun [11]	30	9	9	2.4×10^3	4.5	11.4	29	**12.08**
Optimized coil gun	30	9	9	2.4×10^3	4.5	16.4	60.5	**25.21**

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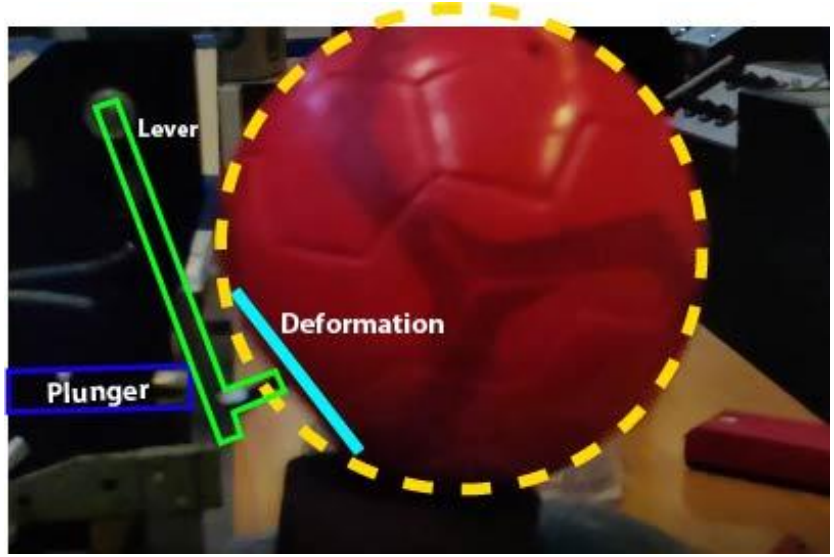
III – Improving robot skills

- Published as research papers :
  - 2020 MDPI Applied Physics : Optimisation of Energy Transfer in Reluctance Coil Guns: Application to Soccer Ball Launchers – *V. Gies et al.*
  - 2019 MDPI Actuators : Modeling and Optimization of an Indirect Coil Gun for Launching Non-Magnetic Projectiles – *V. Gies et al.*
  - 2019 RoboCup Symposium : Modelling and Optimisation of a RoboCup MSL coilgun
- Further work :
  - Taking into account ball deformation in the energy transfer model



RoboCup MSL - Technical challenge 2021
Playing with humans

- Conclusion : 3 keys for playing with humans
  - Playing without digital communications (ready)
  - Improving embedded perception (ready)
    - Results and algorithms will be presented tomorrow in scientific challenge.
  - Improving robot skills : introducing a new coil gun (ready)

- Teams are welcome for **collaborative research** !
- Mechanics, electronics and code **shared on GitHub** after the competition :

  https://github.com/iutgeiitoulon/RoboCup2020

Thanks for your attention
Questions ?