

Nom:

Intelligence Artificielle pour les Systèmes Autonomes (IAA)

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Travail Écrit 1 (TE1)

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Points obtenus:

Note:

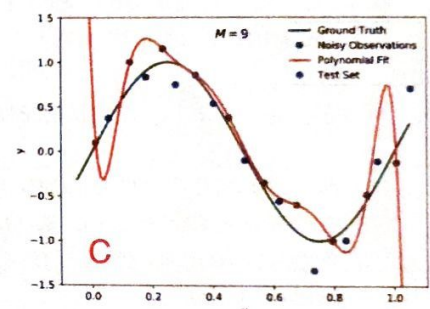
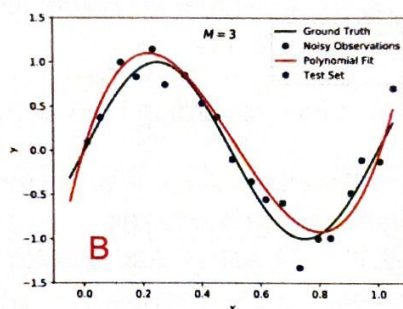
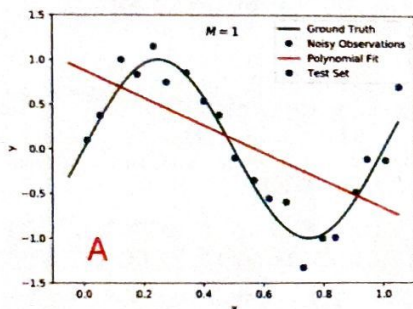
Remarques :

- Ce Travail Écrit comporte 3 parties pour un total de 30 points.
- Durée du travail écrit : **2 périodes (90 minutes)**
- Vous devez répondre sur la feuille de questions
- Vous avez le droit a :
 - Une feuille manuscrite recto-verso
 - Une calculatrice (pas utile du tout, mais vous avez le droit)
- **Aucune réclamation** ne sera acceptée en cas d'utilisation de crayon à papier
- **La couleur rouge** est réservée pour les corrections ; merci de **ne pas l'utiliser**
- Si quelque chose ne vous semble pas suffisamment précisé, veuillez décrire votre hypothèse.
- S'il y a plusieurs réponses possibles, veuillez choisir celle qui vous semble la plus simple.

Question 1 (10 points) : QCM

Veillez cocher la réponse correcte. Pour chaque question il y a **une seule réponse correcte**. Une réponse juste vous donne +1pt. Les réponses incorrectes ont une pénalité de -0.5pt.

- Which of the following sentences is **true** regarding the levels of autonomy proposed by the Society of Automotive Engineers (SAE)?
 - Many cars today (including cars from brands like Tesla, Mercedes and Volvo) are certified level 3 in Europe.
 - Level 2 allows both longitudinal and lateral control of the cars. Driver must monitor the system at all times but can be temporary hands-off.
 - Level 4 corresponds to full automation. The system can cope with all situations automatically and the driver is never required.
 - The SAE proposes 4 different levels of autonomy. Level 0 is not defined.
- Below we provide the performance of 3 models (red line) with respect to a ground truth (in green). Which of the following sentences is **false**?



- Model A suffers from overfitting.
 - Model B is the best performing model.
 - Model C suffers from overfitting.
 - Model A suffers from underfitting.
- Which of the following sentences is **false** regarding the Crazyflie 2.1 drone?
 - The main processor of the Crazyflie 2.1 nanodrone belongs to the ARM Cortex-M family.
 - The GAP8 processor is an ARM processor architecture.
 - The AI-deck equips the GAP8 processor to accelerate AI tasks.
 - The GAP8 is a multi-core accelerator with 8 cores.
 - Which of the following statements is **true** with respect to conditional imitation learning?
 - The Dronet of the Crazyflie drone uses conditional imitation learning.
 - Conditional imitation learning focuses on learning affordances.
 - Conditional imitation learning adds a condition controller to the navigation command (going left, right, straight, for example) to reduce the ambiguity of the environment.
 - Conditional imitation learning is based on the direct perception paradigm.

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5. Which of the following statements is **false** regarding visual abstractions?
- a Having better intermediate representations improve the results of computer vision.
 - b Depth and semantic segmentations often improve the results as they generalize better.
 - c Annotation is a time-consuming task that is required for training in supervised classification tasks.
 - d Having more complex classification by segmenting images into more classes always yields better results. Algorithm performance always increases with number of classes.
6. Which of the following statements is **true** regarding direct perception?
- a It is a hybrid model between end-to-end and modular pipelines that decouples perception from planning and control.
 - b It is more modular than the modular pipeline.
 - c It is less interpretable than end-to-end learning.
 - d Cannot exploit the use of classical controllers such as PID.
7. Which of the following statements is **false** regarding reinforcement learning (RL)?
- a Atari and AlphaGo are typical examples of games often implemented using RL.
 - b One of the benefits of RL is that rewards can be delayed, and are not necessarily instantaneous.
 - c RL is a supervised learning technique where an agent interacts with an environment.
 - d Q-learning is a model-free algorithm for RL.
8. Which of the following statements is **true** regarding the kinematics of a rigid body?
- a A rigid body has 6 Degrees-of-Freedom. A car is considered a rigid body.
 - b A car is only subject to non-holonomic constraints.
 - c A particle can move freely in the 3D space, and therefore it is only subject to non-holonomic constraints.
 - d A particle is a rigid body.
9. Which of the following statements is **false** regarding close-loop control?
- a Closed-loop control uses feedback to minimize the error between measurements taken by sensors and a reference.
 - b A black-box controller (like the bang-bang controller) uses a proportional and a derivative term to switch between two or more states.
 - c There exist different flavors of PID type of controllers, some which incorporate only PI components, PD or P only.
 - d PID control is very often used in autonomous vehicles (specially for robots and drones), either alone or in combination with other types of control.
10. Which of the following statements is **true** regarding rigid body motion?
- a Tire models are not necessary in cars, as we will always assume non-slippery conditions.
 - b Lateral forces in wheels do not need to be considered. Only longitudinal ones are important.
 - c The kinematic bicycle model is a simplification that allows to combine two rear wheels and two front wheels into one (imaginary) rear wheel and one front wheel.
 - d The kinematic bicycle model treats rigid bodies as particles.

Question 2 (10 points) : Questions courtes obligatoires

Veillez répondre à toutes les questions suivantes (2pt par question). Veillez répondre sur la feuille d'énoncé.

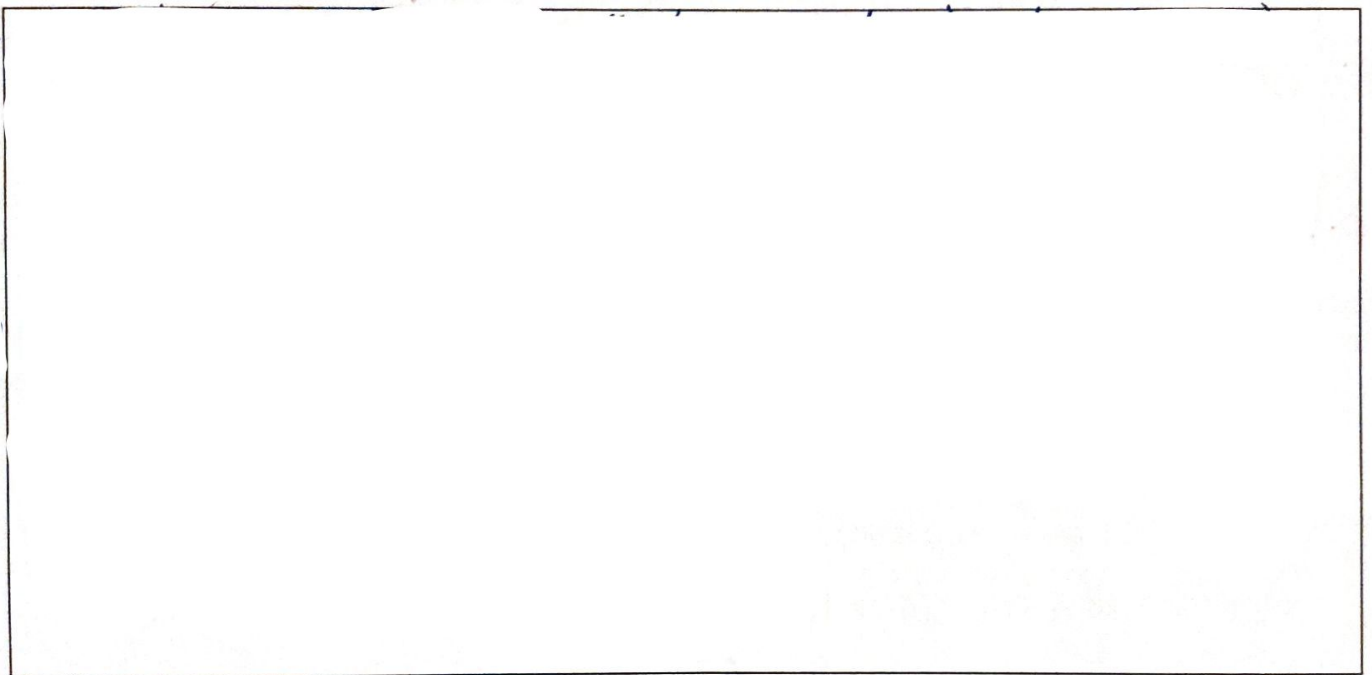
- (a) List 4 types of sensors equipped in an autonomous car today that help in enabling 3D vision and briefly describe their purpose. For each type of sensor, describe their range, resolution, cost and whether they are active or passive.

- (b) Describe 3 features supported in a Level2 certified car today.

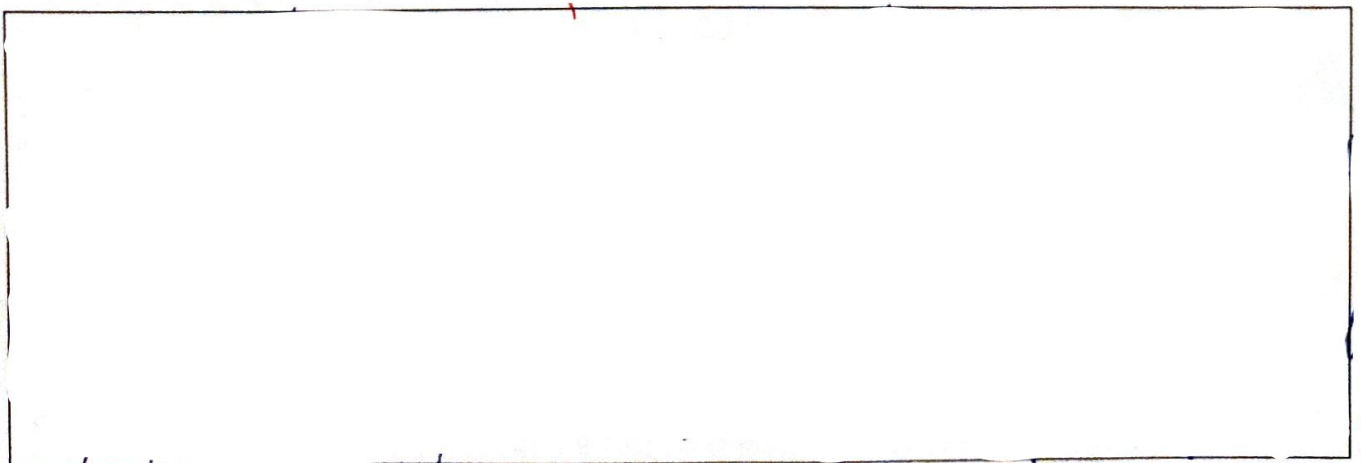
- (c) Describe the basic principles of "imitation learning". Is it a supervised or an unsupervised learning technique? What is one of the major drawbacks of imitation learning? Provide an example in which imitation learning would not work properly and explain why (you can make a drawing if you want).



(d) Describe what is Q-learning. Explain with an example (for instance a mouse trying to find the cheese in a maze) how RL and Q-learning work. What is one of the main disadvantages of Q-learning? What other models are used today to solve the disadvantages of Q-learning?



(e) What is a "Model Predictive Controller" (MPC)? When is it useful? Explain one major advantage with respect to a PID controller.



Question 3 (10 points) : Questions longues à choix

Vous devez répondre aux **2 questions de votre choix (1 question pour chaque partie du cours)**.

Attention ! Si vous répondez à plus de 2 questions, les 2 questions avec les notes plus basses seront prises en compte.

Embedded autonomous systems

- 3.1** Make a block diagram of the Crazyflie drone and use it to explain its main components. What does the drone board contain? And the AI deck board? How do they communicate? Where is the camera located?
- 3.2** What is NVIDIA Drive? What is the purpose of the NVIDIA SDK? Describe the NVIDIA Drive Orin SoC hardware and architecture, providing a block diagram of its main features (inputs, outputs, main blocks).

End-to-end learning and direct perception

- 3.3** Describe the Dronet deep neural network that runs on the Crazyflie drone. What is the topology? What are the inputs and outputs? How is the decision of the Dronet used to control the drone? *(This question refers to the paper: "A 64mW DNN-based Visual Navigation Engine for autonomous nano-drones" by Palossi, Benini et al.)*
- 3.4** What is the main idea behind "Conditional affordance learning" (CAL)? How is this applied specifically to urban environments in the work by Geiger et al.? What is the simulator used? What is the goal? Name a couple of examples of the infractions considered. What are the affordances? *(This question refers to the paper "Conditional Affordance Learning for Driving in Urban Environments" by Sauer, Savinov and Geiger).*

Question 3.3 / Question 3.4