# CSIE 5452, Fall 2021: Quiz 2 Solution

Due December 13 (Monday) 2:30pm

There are totally 50 points. You are expected to use $X$ minutes for a question with $X$ points. When you submit your solutions on Gradescope, please select the corresponding page(s) of each question.

## 1 Short Answers (12pts)

1. (2pts) Which one has the best robustness against snow, fog, or rain? (1) automotive-use camera, (2) automotive-use lidar, (3) automotive-use radar. Select one answer. No explanation is required.

   **Answer:** 3.

2. (2pts) Which one (or all answers) is (are) correct to describe a PID controller? (1) the proportional term is for the current error, (2) the integral term is for the past error, (3) the derivative term is for the future error, (4) all above are correct. Select one answer. No explanation is required.

   **Answer:** 4.

3. (2pts) Explain why 5G Cellular Vehicle-to-Everything (C-V2X) is designed "not" to use a base station to achieve communication.

   **Answer:** To make the communication fast between vehicles.

4. (2pts) Explain why, without human intervention, close-loop control provides better quality of control than open-loop control in most cases.

   **Answer:** It performs control considering the plant status.

5. (4pts) In the lecture, we introduced the *timing conflict graph* $G$ to model the intersection management problem. We can remove some edges in $G$ to get an acyclic graph $G'$ as the solution of the problem. However, we need to build and verify the corresponding *resource conflict graph* $H'$ of $G'$ — if $H'$ is acyclic, then there is no deadlock in the solution $G'$. Please explain what will happen to $H'$ in the special case that the whole intersection is modeled as one single conflict zone. How will you guarantee that there is no deadlock in a solution?

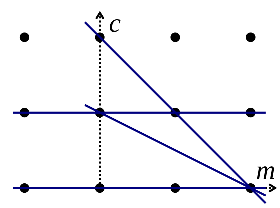
   **Answer:** In the special case, $H'$ is empty, and building $H'$ is not needed — if there is no cycle in $G'$, then there is no deadlock.

## 2 Hough Transform (8pts)

Perform the Hough Transform between the $(x, y)$-space and the $(m, c)$-space, where $y = mx + c$.

1. (4pts) Given $(0, 0), (0, 1), (0.5, 1), (1, 2)$ in the $(x, y)$-space, draw their corresponding lines in the $(m, c)$-space.

   **Answer:**



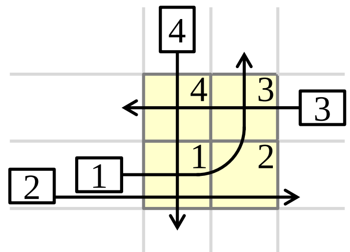

2. (2pts) Write down the coordinates of the point which receives the most "votes" in the $(m, c)$-space.

   **Answer:** $(2, 0)$.

3. (2pts) Given the coordinates above in the $(m, c)$-space, write down the corresponding equation in the $(x, y)$-space.

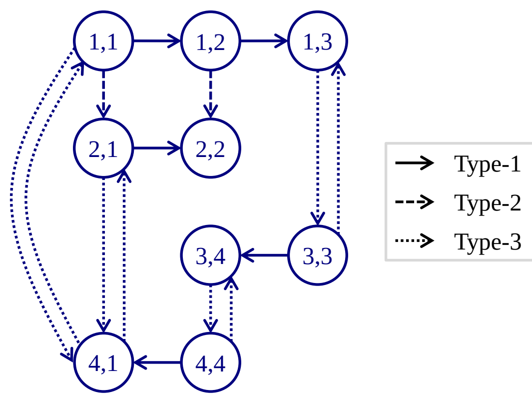
   **Answer:** $y = 2x$.

# 3 Intersection Management (12pts)



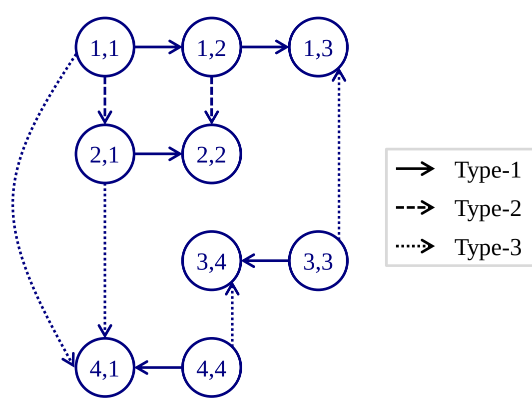

1. (6pts) Given the scenario in the figure above, follow the legend and draw the corresponding timing conflict graph.

**Answer:**




2. (6pts) Following 1., find a DEADLOCK solution which has no cycle in the corresponding timing conflict graph. Follow the legend and draw the corresponding timing conflict graph.

**Answer:**



## 4 Verification (18pts)

1. (6pts) Consider properties, $\mathbf{GF}(p)$ and $\mathbf{FG}(p)$, in Linear Temporal Logic (LTL). Are they equivalent? If yes, explain why they are equivalent; otherwise, show a trace that makes one property true and makes the other property false. If needed, use $\bigoplus$ to represent "$p$ is true" and $\bigcirc$ to represent "$p$ is false" so that a trace can be represented as a sequence of $\bigoplus$ and $\bigcirc$.

   **Answer:** No. $\bigcirc\bigoplus\bigcirc\bigoplus\bigcirc\bigoplus\cdots$ is true for $\mathbf{GF}(p)$ but false for $\mathbf{FG}(p)$.

2. (6pts) Consider properties, $\mathbf{AGEF}(p)$ and $\mathbf{AGAF}(p)$, in Computation Tree Logic (CTL). Are they equivalent? If yes, explain why they are equivalent; otherwise, show an execution tree that makes one property true and makes the other property false. If needed, use $\bigoplus$ to represent "$p$ is true" and $\bigcirc$ to represent "$p$ is false" so that an execution tree can be represented as $\bigoplus$ and $\bigcirc$ in a tree structure.

   **Answer:** No. An execution tree, where the root is $\bigcirc$, any $\bigcirc$'s left child is $\bigcirc$, and any $\bigcirc$'s right child is $\bigoplus$, is true for $\mathbf{AGEF}(p)$ but false for $\mathbf{AGAF}(p)$.

3. (6pts) Given a finite state machine $M$ and its input $\{0, 1\}$ bounded by a weakly-hard constraint $W(m, k)$, meaning that there are at most $m$ 1's for any $k$ consecutive inputs. If $M$ is safe with $W(1, 2)$, is $M$ safe or unsafe with $W(2, 4)$? Explain your answer.

   **Answer:** It cannot be decided. The set of possible input sequences with $W(1, 2)$ is a proper (or strict) subset of the set of possible input sequences with $W(2, 4)$. For example, 1100 does not satisfy the weakly-hard constraint $W(1, 2)$, but it satisfies the weakly-hard constraint $W(2, 4)$. As a result, whether $M$ with input 1100 is safe or unsafe cannot be decided.