Markscheme

November 2018

Computer science

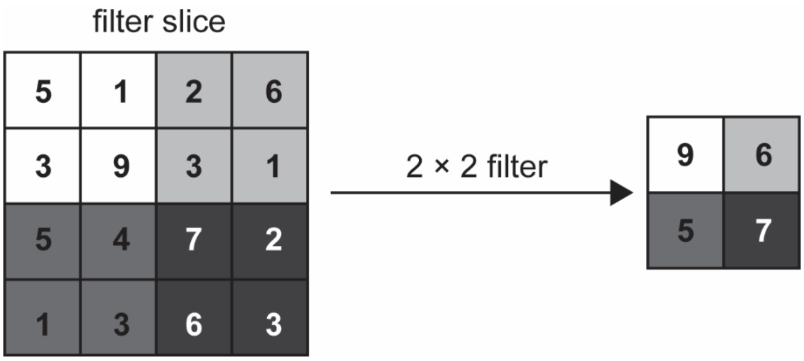
Higher level

Paper 3

1. (a) *Award **[1]** for each requirement up to **[2 max]**.*
That an automated driving system can carry out all of the actions of the task of driving;
In all (roadway and environmental) conditions /
If the automation stops working the ADS brings the car to a safe stop;
Does not require a human driver; **[2]**

(b) *Award **[1]** for each characteristic of max-pooling up to **[2 max]**.*
Max-pooling selects the maximum value / removes all other values;
From each set of values in the receptive field/windows (allow description/example here);
Max-pooling is a process that down samples an input reducing its dimensions / reducing processing;

*Award **[1]** for a correct diagram on its own.*



[2]

2. (a) *Award **[1]** for each reason for the inclusion of both GPS and high density (HD) mapping in autonomous car systems up to **[4 max]**.*
GPS is used to locate the vehicle's position;
This will allow the correct (section of) the HD maps to be used;
GPS will also allow route-planning to take place;
HD maps display the vehicle's location within the HD map / cross references the GPS position to show location / contextualize the position in relation to prominent features;
And will contain detailed features of the route (immediately ahead);
Such as (allow any 1 example) traffic signs, lane markings, prominent features *etc*;
Allowing driving decisions to be planned in advance; **[4 max]**

(b) *Award marks as follows:*
*Award **[2 max]** for a valid consideration of the ethics looking at both sides of the argument (award up to **[2]** for each side of the argument – **[1]** for a reasonable attempt).*

<u>*Sample answer could contain the following:*</u>

The concern could be that:
- Is it ethically correct to put other drivers at risk in this way?
- Public have not given their consent.
- Cars are not in the final state (beta testing) and bugs are present.
- As any errors could result in crashes/injuries.
- Cars should be fully tested away from the public.

The justification could include:
- Fully autonomous cars will vastly reduce accidents, so some risk in testing is acceptable.
- A driver is always present during the beta-testing so risks are minimized.
- Only by testing in real conditions will the systems be perfected / CNN will learn from real conditions.
- Very few deaths have been attributed to autonomous driving. **[4 max]**

***Note:** Only award **[2]** for either side if the argument if the answer captures the main force of the argument.*

3. *Award **[1]** for any of the following mark points up to **[6 max]**.*
For each feature (map) that is being looked for there is one (corresponding) filter;
The depth of the filter (e.g. 5 x 5 x 3) must match the depth of the input / receptive field;
The filter is an array of numbers/weights/matrix;
Each filter moves through the input plane / convolutional layer in steps / filter slides or convolves around the image;
As it convolves the values in the filter and multiplied with the original pixel values of the image (i.e. elementwise multiplications);
At each step (i.e. after each elementwise multiplication) the sum of the dot products of corresponding values in the field and the receptive field is calculated;
This calculated value becomes the corresponding value in the feature map;
A high value will indicate that the feature has been found (in the receptive field);
Every receptive field is looked at / the whole input is looked at;
So the feature can be recognized wherever it is; **[6]**

4. *The answer could include the following:*

- *Deep-learning algorithms.*
  These algorithms can be safely beta-tested on the actual routes that they will be used on, before anybody actually moves into the town, thereby eliminating all risks. The number of different objects that need to be recognized would be greatly reduced again leading to more accurate decisions.

- *Embedded technology.*
  A discussion involving the use of embedded technology/sensors in the infrastructure. This could provide information regarding temporary closed routes / accidents / traffic jams *etc* which would be relayed to all of the taxis using the various protocols (see below).

- *Protocols.*
  The use of vehicle-to-vehicle protocols would allow the broadcasting of relevant traffic information from any one vehicle to all of the others. This may lead to a recalculation of routes on the fly.
  Vehicle-to-infrastructure protocols would relay information regarding pedestrian crossing, priorities (replacing traffic lights) at the next intersection *etc*.

- *Use of HD maps.*
  Due to the limited scope of the project (in terms of geographical size), all routes could be mapped out in precisely producing detailed HD maps. These would allow the deep learning algorithms to make accurate driving decisions.

- *Use of route planning algorithms.*
  Dijkstra's and the nearest neighbour algorithm could recalculate routes on the fly if traffic jams or road closures occur. For the former, the "distances" between points could be changed to reflect the additional time needed to traverse that section and for the latter the link could be removed (temporarily) from the town's route map.

- *The possible drawbacks of using these algorithms.*
  Nearest neighbour might give a solution nowhere near the optimal (with an unacceptably long last leg).
  Or it might not give a completed solution at all, so there would need to be a backup plan.
  The running time of Dykstra's algorithm increases rapidly as the number of nodes increases which would result in a large computational cost for a town graph with a large number of nodes

- *An evaluation of the alternatives.*
  For both bus and taxi projects a brute force algorithm could be considered that would evaluate every possible route in order to arrive at the optimal. But as the number of nodes increase this algorithm becomes too costly.

- *Conclusion.*
  A final measured conclusion is included in which the candidate links together the various points in evaluating the probability of success.

Marks	Level descriptor
No marks	• No knowledge or understanding of the relevant issues and concepts. • No use of appropriate terminology.
Basic 1–3 marks	• Minimal knowledge and understanding of the relevant issues or concepts. • Minimal use of appropriate terminology. • The answer may be little more than a list. • No reference is made to the information in the case study or independent research.
Adequate 4–6 marks	• A descriptive response with limited knowledge and/or understanding of the relevant issues or concepts. • A limited use of appropriate terminology. • There is limited evidence of analysis. • There is evidence that limited research has been undertaken.
Competent 7–9 marks	• A response with knowledge and understanding of the related issues and/or concepts. • A response that uses terminology appropriately in places. • There is some evidence of analysis. • There is evidence that research has been undertaken.
Proficient 10–12 marks	• A response with a detailed knowledge and clear understanding of the computer science. • A response that uses terminology appropriately throughout. • There is competent and balanced analysis. • Conclusions are drawn that are linked to the analysis. • There is clear evidence that extensive research has been undertaken.

[12]

Total: [30]