



EXAMINER' REPORT ON GRADUATION THESIS

Candidate: NGUYEN THI HOA AN

Thesis title: Vehicle Recognition in Regions of Interest within Surveillance Camera Systems

Major: Informatics and Computer Engineering

Code: 8480111.01QTD

Examiner: Associate Professor Dao Quy Thinh

Place of work: Hanoi University of Science and Technology

I. COMMENT:

1. The necessity, scientific significance and practicality of the thesis:

The thesis addresses a relevant and practical problem in intelligent transportation and smart parking systems: determining whether a vehicle is located within a predefined Region of Interest (ROI) using surveillance-camera images. Conventional object-detection methods generally represent a vehicle by a rectangular bounding box. This representation may include a considerable portion of the surrounding background and can lead to inaccurate occupancy decisions when a vehicle is parked diagonally, crosses a parking boundary, or is partially occluded. The candidate therefore formulates the problem as a vehicle keypoint-detection task and uses the four wheel-related keypoints to construct a polygon representing the vehicle footprint. This polygon is then compared with the ROI polygon by a geometric intersection algorithm.



Scientifically, the thesis explores the integration of deep-learning-based pose estimation with rule-based geometric processing. Although the individual techniques are established, their combination is appropriate for the considered application and demonstrates how learned visual features can be complemented by interpretable geometric reasoning. Practically, the work has potential applications in automatic parking-space monitoring, restricted-area surveillance, traffic management, and other smart-city services. The developed software prototype and web-based demonstration also show that the research has progressed beyond model training toward a functional engineering system.

2. Reliability and relevance of the thesis (*which clearly states the non-duplication of the thesis, the relevance of thesis title to thesis content – of content to training major; reliability and modernity of research methodology, etc.*)

The thesis title, objectives, contents, and selected methodology are generally consistent with the Informatics and Computer Engineering major.

The study includes the major stages required for an applied computer-vision project: data acquisition, annotation of vehicle bounding boxes and four keypoints, dataset partitioning, training of YOLOv8-Pose and YOLOv11-Pose models, geometric post-processing, software implementation, and quantitative evaluation. Standard performance indices, including Precision, Recall, mAP50, and mAP50-95, are used to compare the two models. The thesis also reports the inference time and presents several demonstration cases from different camera views.

The proposed processing flow is technically reasonable. In particular, the use of polygon

intersection is more suitable than a conventional rectangular bounding box for determining the physical occupancy of an ROI. The missing-keypoint reconstruction mechanism is also a useful engineering measure for handling partially occluded vehicles. However, the reliability of some conclusions is limited by the experimental design. The final performance of the complete system is mainly illustrated through several examples, whereas a comprehensive test of the final ROI occupancy decision over the whole test set is not reported. The thesis should provide classification indicators for the final decision stage, such as Accuracy, Precision, Recall, F1-score, false-occupancy rate, and missed-occupancy rate. Moreover, repeated experiments, statistical variations, or confidence intervals are not presented. Therefore, the reported results demonstrate the feasibility of the method but do not yet fully establish its robustness and generalization capability.

3. Strong points and weak points of the thesis's content, structure, and format

Strong points:

- The research problem is practical, clearly motivated, and relevant to intelligent transportation and smart parking applications.
- The candidate develops a complete workflow, from data preparation and model training to geometric processing, software integration, and a web-based demonstration.
- The use of four vehicle keypoints to represent the vehicle footprint is more appropriate than a rectangular bounding box for diagonal parking and boundary-crossing cases.
- The thesis compares YOLOv8-Pose and YOLOv11-Pose using the same experimental setting and standard evaluation indices.
- The missing-keypoint reconstruction and polygon-intersection modules provide a practical solution for partially occluded vehicles.
- The thesis is generally organized in a logical sequence and includes figures that help explain the system architecture, data annotation, training results, and software demonstration.

Weak points:

- The literature review is too broad in its description of general computer-vision concepts and early R-CNN/YOLO versions, while the review of closely related work on parking-space occupancy detection, ROI-based vehicle localization, keypoint-based vehicle representation, and segmentation-based approaches is insufficient.
- The reported dataset size is inconsistent. The Abstract and Discussion refer to 900 images, whereas Section 4.1 states that 2,000 images were collected and divided into 1,600/200/200 images. This inconsistency must be corrected throughout the thesis.
- The data description should include the number of vehicles, number of annotated keypoints, distribution across daytime/nighttime and weather conditions, camera locations, and possible overlap between consecutive frames. Without this information, the independence of the training, validation, and test sets cannot be assessed.
- Only YOLOv8-Pose and YOLOv11-Pose are compared. A stronger evaluation should include at least one alternative approach, such as instance segmentation, oriented bounding-box detection, or another keypoint-estimation model.
- The system requirement specifies a latency below 100 ms (pp 24), while the demonstration reports approximately 0.24 s for an image (pp 45) and the conclusion reports about 96.3 ms per image. These values and their measurement conditions should be reconciled.
- The final system is demonstrated on only a small number of images and fixed camera views. More challenging cases should be included, such as adjacent vehicles, partially occupied spaces, severe occlusion, shadows, snow-covered markings, and changes in camera perspective..
- The bibliography is limited and contains incomplete citation information. More recent peer-reviewed publications should be added, and all references should be formatted consistently.

- The manuscript still contains grammatical, typographical, caption, notation, and formatting inconsistencies. A careful English-language and formatting revision is required.
- Section 6 lists a publication on waste detection, but its direct relationship to the thesis topic is not explained. The candidate should clarify whether and how this publication contributes to the thesis.

II. QUESTION (Optional)

1. Why did you choose a four-keypoint pose-estimation approach instead of instance segmentation or oriented bounding-box detection for determining vehicle occupancy within an ROI? Please discuss the advantages and disadvantages of these alternatives.
2. The keypoint-detection mAP50 is approximately 55%. How does this level of keypoint accuracy affect the final binary ROI occupancy decision? Please provide or explain the final system-level Accuracy, Precision, Recall, and F1-score.
3. The thesis reports different dataset sizes and different processing times in several sections. What is the exact dataset used for training, validation, and testing, and how was the inference time measured?

III. CONCLUSION *(which clearly confirms the extent of satisfying requirements for a master thesis; whether the thesis can be submitted to the master thesis examination committee)*

The thesis presents a practical computer-vision system for vehicle recognition within predefined regions of interest by combining YOLO-based pose estimation with geometric polygon processing. The candidate demonstrates an adequate understanding of deep learning, image processing, dataset preparation, and software implementation, and has developed a functional prototype with experimental results. The work is relevant to the Informatics and Computer Engineering program and has potential practical value.

Nevertheless, several issues should be revised, particularly the inconsistent dataset description, insufficient related-work analysis, and inconsistencies in terminology and processing-time reports. Subject to satisfactory clarification of these issues and appropriate revision of the manuscript, the thesis meets the general requirements of a master's thesis. I recommend that the thesis be submitted to the Master's Thesis Examination Committee for defense.

Hanoi, July 10th, 2026

EXAMINER



DAO QUY THINH

HOC



Hanoi, ... 11/7 ... / ..., 2026

**RESOLUTION OF THE MASTER THESIS
EXAMINATION COMMITTEE**

Pursuant to the Decision No. 2850...../QĐ-DHQGHN issued on 24/6.../2026 by President of Vietnam National University, Hanoi on establishing the Master thesis examination committee to examine the master thesis of the student Nguyễn Thị Hòa An (date of birth: 24/5/2001)

Thesis title:

Vehicle Recognition in regions of interest within surveillance camera systems

Major: ICE

Code: 848 0111 01 QIP

The thesis examination committee conducted a meeting at 9...00 (hour/minute), on 11/7.../2026 at VNU - International School.

After the candidate's presentation on the thesis, opponents' review, committee members' comments, candidate's answers, the committee deliberated and came to a conclusion:

1. The necessity, scientific significance and practicality of the thesis topic

- Necessity: Traditional bounding boxes include unwanted background noise, causing high error rates when vehicles overlap or park diagonally within ROIs.

Scientific significance: shifts the problem from traditional object detection to pose estimation, combining deep learning with a rule-based polygon intersection algorithm to map the vehicle's exact footprint.



2. Structure, research methodology, references, etc., of the thesis

- Structure: suitable
- Methodology: employs manual dataset labeling, empirical deep learning training and mathematical vector modeling
- References: ~ 11 entries

3. Research outcomes:

- Detection Accuracy is good
- Successfully built a post-processing algorithm to reconstruct missing coordinates of obscured wheels and calculate precise ROI occupancy.

4. Limitations and requests for thesis correction (if any):

- clearly state the contribution and research gap.
- follow the examiner's report.

Thesis marked: ...8.9./...10.

Outcome of master thesis defense of candidate

Qualified: ☒

Unqualified: ☐

(The thesis is qualified if the average score marked by the Committee is 5.5 or higher).

This resolution is passed by ..03./...03 members of the Committee.

**SECRETARY OF THE THESIS
EXAMINATION COMMITTEE**

**CHAIR OF THE THESIS
EXAMINATION COMMITTEE**



Phạm Thị Việt Hương



Nguyễn Quang Thuận

**Certification by VNU - International School
P.P. RECTOR
OFFICE OF ACADEMIC AFFAIRS**


Hoàng Tuyết Minh



Hanoi,11/7....., 2026

MINUTES OF MASTER THESIS DEFENSE

The master thesis defense session of student: ..Nguyễn Thị Hòa An.....
(date of birth: 24/5/2001) was conducted at (hour/minute), on/...../202...
at VNU - International School.

Thesis title:

Vehicle Recognition in regions of interest
within surveillance camera systems

Major: ICE

Code: 848 0111 01 QTP

Members of the Master thesis examination committee are present: 3./3

No	Full name	University/ Organizations	Role in Committee	Note
1	TS Nguyễn Quang Thuận	VNU - IS	Chair	
2	PGS.TS Đào Quý Thịnh	HUST	Opponent	
4	TS. Phạm Thị Việt Hương	VNU - IS	Secretary	

PART I: INTRODUCTION

1. Representatives of VNU - International School made welcoming remarks including:

- Introduction of the master thesis defense and participants;
- Announcement about Decision of the President of Vietnam National University, Hanoi on establishing the Master thesis examination committee (Decision No. 285/QĐ-ĐHQGHN issued on 24/6/2026.).

PART II: THESIS DEFENSE SESSION

1. Dr. Nguyễn Quang Thuận - The Chair led the Master thesis examination committee.

2. Dr. Pham Thi Viet Huong - The Secretary of the Committee announced the scientific background and conditions for master thesis defense of the candidate (candidate's scientific background file and academic results are attached).

3. The candidate Hoa An made a presentation on the thesis.

4. Assoc. Dr. Dao Quang Thinh - Opponent commented on the thesis (with attached documents).

5. Questioning period from members of the Committee:

1. Why do you choose 4 keypoints to detect the ROI?

2. Does MAP SD ~ 55% affect to ROI?

Evaluate some criteria to determine ROI?

6. Candidate's answers

1. because of the angled perspective of the parking lot

2. Despite the low mAP for keypoints, the thesis demonstrates the system still successfully determines parking occupancy

7. The Secretary of the Committee commented on the thesis conducting progress of the candidate (with attached document).

8. Committee's Deliberations:

- Election of Vote counting committee:

1. Chair: Pham Thi Viet Huong

2. Member: Dao Quang Thinh

- The examination committee voted by secret ballot.

- The vote counting committee:

+ The Chair reported the vote counting result (with attached vote counting record).

- The Examination committee deliberated and came to a conclusion on the thesis examination by reaching a consensus on the assessment resolution on the thesis. The resolution concluded:

The student's thesis satisfies the requirements of a master's thesis with revisions.

PART III: OUTCOME OF THE EXAMINATION PROCESS

1. The Chair of the Vote Counting committee announced the result of the ballot on the thesis examination.
2. The Chair of the Examination Committee announced the resolution on the thesis examination.
3. The Chair of the Examination Committee made statements and gave controls to the organizer.

The thesis defense session ended at ...9...45... (hour/minute), on 11/7.../202...

Hội đồng đánh giá đề án nhất trí thông qua đề án của học viên ...Nguyễn Thị Hòa An... đạt yêu cầu với kết quả (thang điểm ...): 8.9 điểm (Bằng chữ: ...eight point nine...). Học viên cần chỉnh sửa một số nội dung theo yêu cầu Hội đồng và nộp đề án hoàn thiện cho Trung tâm Thông tin - Thư viện, Đại học Quốc gia Hà Nội theo quy định.

SECRETARY OF THE THESIS
EXAMINATION COMMITTEE

CHAIR OF THE THESIS
EXAMINATION COMMITTEE


Phạm Thị Việt Hương


Nguyễn Quang Thuận

Certification by VNU - International School
P.P. RECTOR
OFFICE OF ACADEMIC AFFAIRS


Hoàng Tuyết Minh



Hanoi, ... 11/7/2026

MINUTES OF VOTE COUNTING COMMITTEE OF THE MASTER THESIS EXAMINATION COMMITTEE

Pursuant to the Decision No. 2852/QĐ-DH-QGHN issued on 24/6/2026 by President of Vietnam National University, Hanoi on establishing the Master thesis examination committee, the committee conducted a meeting at 9:00 (hour/minute), on 11/7/2026, at VNU - International School to examine the master thesis of the candidate ... Nguyễn Thị Hòa An ...

Thesis title:

Vehicle Recognition in regions of interest within surveillance camera systems

Major: ICE

Code: 848 011 01 RTP

The vote counting committee was voted:

1. Chair: ... Phạm Thị Việt Hương ...

2. Member: ... Đào Quý Thuận ...

The number of members presenting is 03/03, the members who are opponents are 01/03

Number of votes distributed to members: 03

Number of unused remaining votes: 0

Number of valid votes: 03

Number of invalid votes: 0

Number of votes for the score 8.9 is: 3

Number of votes for the score is:

Number of votes for the score is:



Average score: 8.9 / 10

(In text: eight point nine)

Note: The thesis score is the average of scores marked by the examination committee's members presenting in the thesis defenses session, taken to one decimal place and not rounded.

**MEMBER OF THE VOTE
COUNTING COMMITTEE**

(sign with full name)



Đào Quý Thuần

**CHAIR OF THE VOTE
COUNTING COMMITTEE**

(sign with full name)



Phạm Thị Việt Hương

Certification by VNU - International School

P.P. RECTOR

OFFICE OF ACADEMIC AFFAIRS



Hoàng Tuyết Minh

DEFENSE SCORE SHEET FOR MASTER THESIS

Pursuant to the Decision No. 2.8.50.../QĐ-ĐHQGHN issued on 24./06.../202... by President of Vietnam National University, Hanoi on establishing the Master thesis examination committee, the committee conducted a meeting at (hour/minute), on 11/07.../2026. at VNU - International School to examine the master thesis of the candidate Nguyễn Thị Hòa An

Thesis title:

Vehicle recognition in regions of interest within surveillance camera systems

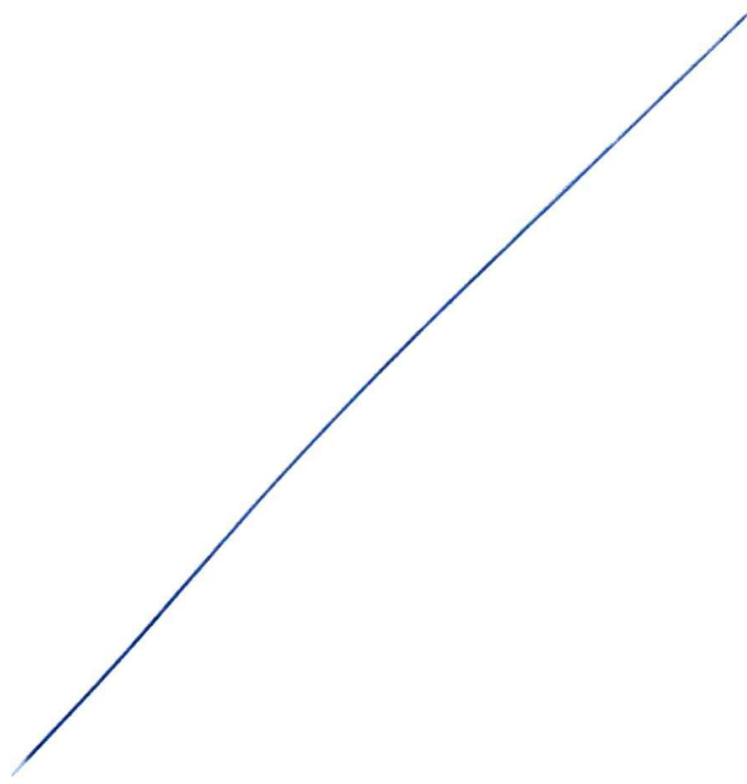
Major: ICE

Code:

Comments:

The thesis is quite good

- Rewrite/reconstruct the thesis with chapters
- References is not standard forms.
- Images should be cited.
- Formulas need to be explained clearly.
- It is better if the thesis makes comparison about the proposed method and the existed one.

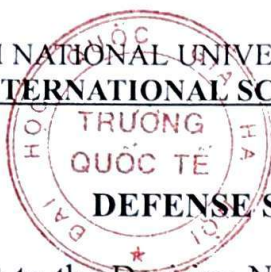


Result: (The mark of each committee member is on-point scale, possibly odd to one decimal place):

- In number: 8.9 marks
- In text: eight point nine marks

Hanoi, 11/7, 2021
Marker

Nguyen Cao Thuan



DEFENSE SCORE SHEET FOR MASTER THESIS

Pursuant to the Decision No. 2850.../QĐ-ĐHQGHN issued on 24./6.../2026.. by President of Vietnam National University, Hanoi on establishing the Master thesis examination committee, the committee conducted a meeting at (hour/minute), on 11./7.../2026.. at VNU - International School to examine the master thesis of the candidate Nguyễn Thị Hoà An

Thesis title:

Vehicle recognition in regions of Interest within surveillance camera systems.

Major: ICE

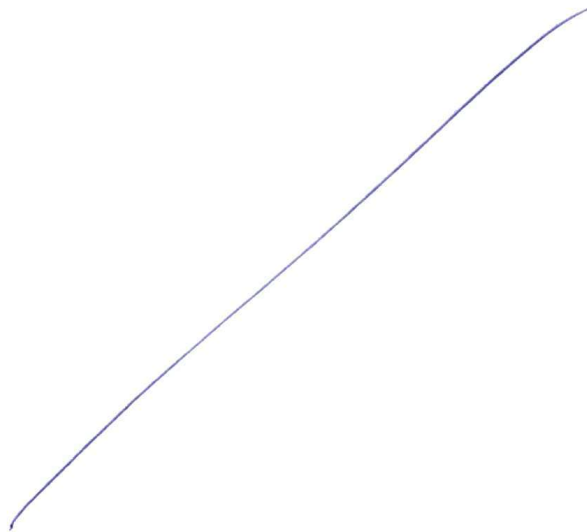
Code: 848 0111.01&TP

Comments:

- clearly restate the contribution and research gap

- check again typos and grammar





Result: (The mark of each committee member is on-point scale, possibly odd to one decimal place):

- In number: 8.9 marks
- In text: ~~eight~~ point nine marks

Hanoi, 11 / 7 / 2026
Marker

Phạm Thị Việt Hương

VIETNAM NATIONAL UNIVERSITY, HANOI
INTERNATIONAL SCHOOL

SOCIALIST REPUBLIC OF VIETNAM
Independence - Freedom - Happiness

DEFENSE SCORE SHEET FOR MASTER THESIS

Pursuant to the Decision No. 2850.../QĐ-ĐHQGHN issued on 24./06./2026. by President of Vietnam National University, Hanoi on establishing the Master thesis examination committee, the committee conducted a meeting at (hour/minute), on 11./7.../2026. at VNU - International School to examine the master thesis of the candidate Nguyễn Thị Hòa An

Thesis title:

Vehicle recognition in regions of interest within surveillance camera systems

Major: ICE

Code:

Comments:

Good



Result: (The mark of each committee member is on-point scale, possibly odd to one decimal place):

- In number: 8.9 marks
- In text: Eight point nine marks

Hanoi, July 11th 2026

Marker


Dao Quy Thinh