Thesis Reviewer‘s Report

I. IDENTIFICATION DATA

Thesis title:	**Machine Learning Approach to Ionizing particle Recognition using Hybrid Active Pixel Detectors**
Author’s name:	**Bc. Petr Mánek**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Computer Science
Thesis reviewer:	Radim Šára
Reviewer’s department:	Cybernetics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

Evaluation of thesis difficulty of assignment.

The project required understanding the basics of physics of particle interaction with matter, structuring the computational problem, reading relevant computer vision literature, formulating the individual computational tasks, selection of suitable algorithms, parameter learning/tuning, software development, experimental proof of concept and an experiment on real data. In this sense the assignment was quite challenging for a Master’s project.

Satisfaction of assignment **fulfilled**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

In my opinion the assignment was fulfilled in all points set forth.

Methodology **correct**

Assess that student has chosen correct approach or solution methods.

The author structures the problem to segmentation to individual tracks, track parameter fitting, track type recognition, and a statistical decision on the detection saliency. This is a possible and valid approach, although I would question the need for explicit segmentation prior to parameter fitting. See also my remarks below.

Technical level **A - excellent.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The author has shown an ability to work with literature sources, formalize a detection problem based on the knowledge, choose a correct solution, improve published methods where needed, and experimentally verify all major design choices.

Formal and language level, scope of thesis **A - excellent.**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The thesis is structured well, it reads easily, and it is written in very good English with very few mistakes and typos, if any. I only have two remarks:

1. A sentence cannot start with a mathematical symbol, citation, or other reference (e.g. on pp. 30, 31).
2. If a sentence contains numbers and all of them are zero to nine then they are written in words (e.g. on p. 10 and elsewhere) .

Selection of sources, citation correctness **A - excellent.**

Present your opinion to student’s activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

In my opinion the student used relevant sources. Bibliographic references follow the usual standard. In some details it is not fully clear what was the contribution of the student and what was taken from the literature.

Additional comments and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

I consider the thesis to be of excellent quality. All goals were met. The presentation is well-structured and clear. Technical problems are approached and solved in a correct way. The work builds on a prior art in the domain. Experiments demonstrate the utility and performance of the method reasonably well, with some reservations expressed in Section III of this review.

There are a few minor points that are unclear:

1. Prior to Sec 2.4.1 it appears as if the data lattice was 2D and in Sec 2.4.1 it seems it is 3D.
2. Some symbols are used for different mathematical objects, eg. θ is used as a line parameter (Fig. 3.1a) and later as an incident angle (Fig. 3.3).
3. What are $\boldsymbol{\mathcal{M}}$, $\boldsymbol{F}$, $\boldsymbol{f_F}$ in expression (3.5)?
4. How were the detections matched to ground truth in Sec. 5.2.2?
5. What is the meaning of the “training time” in the case of plain (“naïve”) kNN classifier?
6. What kind of Ball Tree was used? Time performance might differ significantly, depending on the Ball Tree construction algorithm.
7. Was it impossible to compare the results with previous published work?

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

I have several comments that might seed a discussion during the defense:

1. How was the stopping time $\boldsymbol{r}_{\mathbf{max}}$ chosen in RANSAC (Alg. 3 on p. 25)? Could we estimate the value on-line from inlier counts as in RANSAC working with discrete measurements?
2. Why RANSAC is a better choice in Alg. 5 (p. 27) than an MCMC sampler?
3. I am not clear about the Trajectory Fitting phase. I understood that we are only deciding on the starting and ending point on the line provided by the segmentation phase. If that was the case then RANSAC would not be a good choice. For instance, one could use a simple Markov chain to describe the structure of the detection (we are looking for a contiguous interval on a discretized line, which can be achieved with a simple language of three symbols: <before-segment>, <on-segment>, <after-segment> and rules that only allow transitions BS->BS, BS->S, S->S, S->AS, AS->AS.
4. Why close parallel tracks as in Fig. 5.1.c are excluded from the reference dataset? They are clearly separable in Fig. 5.1. How would one decide if two tracks are separable or not? In my opinion such exclusion skews the results towards better performance.
5. Similarly, limiting the Trajectory Fitting experiment to axis-parallel tracks also skews the results. Furthermore, it is not clear if such track configurations are physically meaningful in the detector.
6. It is not fully clear why true negatives were not considered in the experiment in Sec. 5.2. A detector should be able to report absence of an object, so the test set should also contain some frames without any tracks.

Assuming that the student can clarify the seven points listed under Additional Comments, I suggest the submitted thesis be graded **A - excellent.**

Date: **6.6.2018** Signature: