



Referee report

on a dissertation

for the acquisition of the educational and scientific degree "doctor"

in professional direction 4.1 Physical Sciences,

under the defense procedure at the Institute of Optical Materials and Technologies,
Bulgarian Academy of Sciences

The report is prepared by Prof Asen Pashov, Sofia University St. Kliment Ohridski", Faculty of Physics, in his capacity as a member of the scientific jury according to Order No. 24/19/12/2024 of Director of the Institute.

Dissertation topic: "Analysis and compression of dynamic speckle"

Author of the dissertation. Mikhail Levchenko

The PhD thesis has been written within a joined doctoral program between the Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences and the Technical University of Berlin under the supervision of Prof DSc Elena Stoykova and Assoc. Prof Violeta Madjarova, PhD.

Information on the submitted documents

The list of documents submitted by Mr Levchenko includes the PhD thesis, an extended Abstract (Synopsis), CV, Diploma, List of publications, Table with correspondence with the National Requirements for the educational and scientific degree "doctor", full text of all publications.

A brief look at the Table ensures that Mr Levchenko meets the National requirements. With two Q2 papers and 4 SJR papers the candidate exceeds the formal requirements in group D nearly three times!

I do not see a Separation protocol, so I assume that the papers within this procedure are not going to be used by any of the coauthors for obtaining a doctoral degree.

Scope of the thesis

The study of Mr Levchenko is in the field of dynamic speckles. In the thesis a brief review of the achievements and the problems in the area are presented. Based on those, the author formulates several tasks and concentrates on them within the three specialized chapters of the thesis. I would summarize the tasks as follows:

1. Improvement of existing algorithms for dynamic speckle imaging (DSI) in cases such as non-uniform illumination, higher temporal resolution, presence of out-door noise etc.
2. Optimization of existing methods for image compression
3. Demonstration of the benefits achieved in p.1 and p.2 in real experiments.

In Chapter 2 some analyses of the dynamic speckle imaging are presented, based on them the author selects methods to be applied in a non-uniform illumination of the object. Some improvements on the pointwise dynamic speckle imaging are proposed, as well as an intensity-based algorithm is developed for tracking fast changing processes with high temporal resolution. Noise analysis in outdoor dynamic speckle measurement is presented in the same Chapter, motivated with the intention of the author to build a portable low-cost device for outdoor applications.

In Chapter 3 Mr Levchenko reviews four algorithms for image compression JPF, JPG2000, SVD and PCA. He applies them for compression of speckle images and makes a critical comparison. A novel PCA-based temporal compression algorithm for lossy compression of a set of speckle images is proposed.

In Chapter 4 the results of three experiments are presented. The first is a low-cost out-door device for DSI, designed and tested by the author. Critical evaluation of its performance is presented. The second is the implementation of DSI techniques with a high-speed camera for impact testing of composites. This experiment is performed at the University of Delft, the Netherlands. In the third experiment Mr Levchenko and coauthors demonstrate the application of DSI for detection of hidden defects.

General description of the candidate's scientific achievements

The results of the work of Mr Levchenko are summarized in a separate section “**Author contributions in the dissertation work**” In this section the reader can find a summary of the main results of the dissertation, most of them published in scientific papers. However, from this I cannot evaluate the personal contribution of Mr Levchenko. From the papers one can see that the PhD student has worked with more than 10 coauthors and such information should have appeared either in the thesis or in the accompanying documents. I believe this will be clarified during the defense in favor of the candidate.

Apart from this remark, the content of the thesis and the way it is presented makes a very positive impression. The author demonstrates understanding of mathematical methods behind the analyses and suggests improvements and optimizations. He is able identify unsolved problems which accompany the tasks he approaches and proposes working solutions. The theoretical algorithms are verified with simulations and real experiments. It seems to me that Mr Levchenko is already a formed young scientist.

I should note the numerous presentations at scientific events in the form of posters or oral presentations. I take it as a sign that the coauthors assess highly his ability to present their common work.

Critical remarks

As I already said, my general impression is very positive. However, as a specialist in a quite different area in Physics, I want to address some critical remarks, some of which need to be clarified during the defense.

1. At the beginning, I am missing a more general overview in which the author positions the dynamic speckle imaging among other analytical techniques. What are the problems they are designed for; how can one compare their performance and so on. Such a review will help the reader to better understand the goals of the research. It will also demonstrate that the candidate has a much broader overview. In fact, within the thesis one can find pieces of information I am writing about, but not in the compact form I would expect to see it.
2. In some parts of the thesis, I would expect more information. For example:
 - a. I found quite few information about the laser sources. The word coherent is used many times in the thesis, so I would expect a note saying what is the line width of the lasers. I am curious, would the speckles pattern be stable in time if the laser operates in a multi-mode regime. I would expect at least a brief comment on this and a note that the laser sources used in the experiments meet the necessary requirements for coherence.
 - b. In the introduction, section 1.2, some basic concepts are introduced. In subsections 1.2.1 - 1.2.3 there is only one reference [5], where the theoretical description of the speckles is developed. However, most of the statements in these subsections do not follow directly from the presentation, I think they are not original results of the candidate, so they also need a reference.
 - c. It is supposed that the reader is familiar with the JPEG compression, which is not obvious among physicists. The same is valid for SVD. This abbreviation comes from the linear algebra, and, for me, it cannot be used as a method for compression of images without additional comments. A deeper insight in these (and also other) techniques will help the reader to assess the author achievements and also to convince him/her that the candidate understands them and is not using them as "black boxes"
3. I have got the impression that the work associated with the thesis requires non-trivial data processing. In the introduction one reads that program scripts for simulation and data processing are written in Matlab and Python. Who was the author of these programs? From the CV we can learn that Mr Levchenko has strong knowledge in programming and hardware development, I hope they were used during the study

To summarize, I have got the impression Mr Levchenko has significant participation in most of the topics studied. He has knowledge in the theory of the problem, experiments, data collection and processing. However, among the numerous technical details (which are by no

means unimportant), he should have clearly highlighted his personal contribution or, as alternative, acknowledge the contribution of the other coauthors.

Conclusion

Based on the thesis and the accompanying documents I convinced myself that the scientific achievements of Mr Levchenko meet the requirements within the national regulations of Republic of Bulgaria and the local regulations of the Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences for the acquisition of the educational and scientific degree "Doctor" No plagiarism has been found in the PhD thesis, abstract and scientific works he submitted. I **recommend** the scientific jury award **the educational and scientific degree "Doctor"** in professional direction 4.1 Physical Sciences to Mr Mikhail Levchenko. According to the requirements of TU Berlin and based on my impression while studying the thesis I mark the quality of the study and the presentation as very good.

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Sofia

