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Professor Jan Flusser
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Dear Prof. Flusser:

This letter is in response to your request of an assessment of Dr. Iveta Hnetynkova's Habilitation Thesis. My research interests overlap those of Dr. Hnetynkova in the broad areas of inverse problems and numerical linear algebra. Because we attend many of the same conferences, I have known Dr. Hnyetynkova for many years (since she was a PhD student), and we have had many conversations on our mutual research interests. However, we have no formal research collaborations, and I have no recollection that we served together on any committees.

First let me begin at the end: The research in Dr. Hnetynkova's Habilitation Thesis is spectacular. The work thoroughly studies an important challenging applied mathematics problem that arises in many applications, it is mathematically rigorous, and requires nontrivial algorithmic and computer science techniques for implementations. The body of work shows that Dr. Hnetynkova has developed a strong, independent research program with an upward trajectory, and there is ample evidence to show that she is internationally recognized as an outstanding computational mathematician. In the U.S., this body of work would certainly qualify her for Full Professor position in a first class applied mathematics department.

The research in Dr. Hnetynkova's Habilitation Thesis focuses broadly on simultaneously computing approximate solutions of a large-scale linear system with multiple observations. A substantial amount of previous work has been done on the relatively easy least squares (LS) problem, where one only assumes errors in the observations; it is assumed the mathematical model is known exactly. However, if one also assumes errors in the mathematical model, then this can often be formulated as a "total" least squares (TLS) problem. Previous work had been done for TLS problems when there is only one set of observations, but relatively little was known for the case of multiple observations. In fact, this turns out to be surprisingly complicated to understand. In particular, the first part of the thesis summarizes the work in seven papers that focus on analysis of existence and uniqueness issues. All of these seven papers are published in top tier journals in computational and applied mathematics.

The second part of the Habilitation Thesis focuses on TLS formulations of ill-posed inverse problems. Inverse problems are ubiquitous in engineering, science and medical applications. An example that arises in geophysics is the problem of reconstructing a picture that represents material in underground layers of the Earth, in a defined area (e.g., 1 hectare field), without removing the soil. Geophysicists attack this problem by placing source explosive devices in various locations of the field, and sensors that measure sound waves in other locations. When the explosive devices are detonated, they emit sound waves that travel from the sources through the ground, reflecting off the various underground layers, before being measured at the sensors. Reflection properties depend on the material in the various underground layers. The relationship between these reflection properties and the sound waves are connected by complicated mathematical equations. Solving these mathematical equations (i.e., solving the inverse problem) provides information needed to reconstruct a picture of the underground layers. A very similar application arises in medical imaging, such as tomography.

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Inverse problems are notoriously difficult – small changes in the model or measurements can lead to large changes in the computed solution. To alleviate this instability, it is necessary to employ regularization techniques. Previous work had been done to develop a so-called "truncated" TLS (TTLS) method, and on incorporating a damping term (referred to as Tikhonov regularization) in the solution. Previous analyses had established some relationships between the mathematical model and the observations in order to partially understand the regularization effects of these techniques, but the work was complicated and woefully incomplete. Dr. Hnetynkova's papers summarized in this part of the thesis use a unique combination of skills to attack these problems and to solve many open problems; this includes numerical linear algebra, computational statistics, and optimization. This wide range of skills is evident in the venues where these papers have been published (again in top tier journals).

When looking at the combined set of papers summarized in the thesis, I think it is obvious that this work shows incredible productivity. The varied list of journals is an indication of the broad impact made by Dr. Hnetynkova's work. Moreover, as I alluded to earlier in this review, a close inspection of these papers reveals work that has breadth and depth; the work is mathematically rigorous, develops new and sophisticated numerical algorithms, and includes substantial verifications on nontrivial problems in realistic applications. Dr. Hnetynkova has clearly demonstrated her talent for mastering mathematical analysis along with algorithm and software development. It is not an exaggeration to say that this work represents a true tour de force. I can only hope that Dr. Hnetynkova will consider writing a book that collects this work into a single location – as far as I know, there is only one good book on TLS problems, and it is old. There is a need and I think a good market for a more up-to-date treatment on the topic that includes the large body of Dr. Hnetynkova's work.

Dr. Hnetynkova has the talent, knowledge and drive to continue to make important research contributions and to continue being a leading figure in the computational mathematics research community. I expect many more great things from her in the years to come.

In summary, the work in Dr. Hnetynkova's Habilitation Thesis provides clear evidence that she has established herself as a leading independent scholar who is making important and innovative contributions to the field of computational science. Her research has the momentum and trajectory to continue to make significant advances in the field. In the U.S., Dr. Hnetynkova's work and her strong reputation in the field would certainly qualify her for Full Professor position in a first class applied mathematics department.

Please let me know if you have any questions or need any further information.

Sincerely,

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