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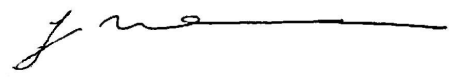
Dear Colleagues,

This is a letter of reference for **Ravil Mussabayev** who is applying for a position in your University. Mussabayev was my PhD student at the Department of Mathematics of the University of Washington (UW) graduating in 2024. I have known him since the summer of 2017 when he came to visit during the summer. I was very impressed by him and I recommended that he be accepted as a graduate student in the PhD program the following year. In his impressive PhD thesis he has worked completely independent on clustering and produced very strong results. I describe briefly below some of them.

Clustering is a foundational task that groups similar objects within a set, revealing inherent structures and relationships. Recently, unprecedented data growth has given rise to the notion of big data, which requires fast yet accurate clustering methods. When dealing with big data, where the number of data points is the standard Minimum Sum-of-Squares Clustering (MSCC) which is NP hard gives rise to the MSCC of Infinitely Tall Data (MSSC-ITD) Mussabayev has proposed a series of simple and cutting-edge MSSC-ITD algorithms, featuring: 1. Scalability to big data through problem decomposition and parallel processing; 2. Best accuracy and efficiency across small, large, and big data without relying on complex metaheuristics or meta-ideas; 3. Further improvement through the use of an advanced metaheuristic, as well as dynamic sample size adjustment using competitive stochastic optimization. Furthermore, he synthesize these recurring concepts and meta-ideas into a novel optimization metaheuristic, which he introduced as Variable Landscape Search. Furthermore, Mussabayev synthesized these recurring concepts and meta-ideas into a novel optimization metaheuristic, which we introduce as Variable Landscape Search. He alsoconducted a comprehensive review of K-means optimization methods in the big data context, and evaluate their performance through extensive experiments on a diverse range of real-world datasets, covering small, large, and big ones. As I had said earlier this is an impressive thesis, one of the best I have seen in the Math Departmentm written completely independent.

In summary Mussabayev is an excellent researcher of great promise. He is very talented, hardworking, full of ideas and new projects. I recommend him for the position in the strongest possible terms.

Sincerely,



Gunther Uhlmann
Elaine F. and Robert R. Phelps Endowed Professor