

Review report

of the doctoral dissertation “**Behaviour-Based User Authentication For Financial Services**” authored by **Piotr Kałużny** for the doctoral dissertation public defence procedure at **Poznań University of Economics and Business**

Title of the thesis:	Behaviour-Based User Authentication For Financial Services
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Institution:	Poznań University of Economics and Business
The pursued degree	Doctoral degree in the field of Social sciences in the discipline of Economics and Finance
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The doctoral dissertation “**Behaviour-Based User Authentication for Financial Services**” addresses the economically important and technologically advanced area of providing secure digital financial services.

The **Introduction** section builds background information for identifying problem areas for investigation. The author demonstrates extensive knowledge in the area and highlights significant demand of the research solutions in the area of card-not-present (CNP) type of financial fraud and the perspective of solving it via proposal in the area of mobile access to the financial services. The scope of the problem and the potential impact of the solution are substantiated by relevant statistical information.

The author presents a list of problems facing financial sector and existing technologies for further investigation, yet it can be noticed, that the grouping/classification and ranking of these problem areas could increase coherence and highlight main directions of further investigation of the dissertation. The proposed solution of behaviour-based user authentication is based on extended interpretation of the term “biometrics”, including both physical, and behavioural characteristics.

The complexity of the domain field and its interdisciplinary intertwining areas of financial services, mobile touchscreen access solutions, and user behavioural characteristics, invoke wide usage of concepts, tracking methods and computational approaches, belonging to different research fields. It can be noticed that the contribution of the dissertation may be generalized to the area of applying touchscreen devices for user authentication in the variety of domains not limited to financial services, however its economic value in the financial fraud and risk detection domain is clearly shown.

The author has outlined a broad field of investigation with numerous components and factors affecting the selected research problem. This results in formulation of five research questions RQ related to the complex research problem and deriving five research goals RG, analysed in the consecutive chapters of the dissertation. The consistency of formulation research problem, main goal, research questions and goals, and the thesis statement well reflect the complexity of the approach of the author, breadth and width of the research field. However, some questions emerge for coherences of the statements:

a) Positioning of the aspect of authentication in the “transaction level” is not clearly defined. Although its relevance to the research is shown in the problem statement, the research goals and the thesis statement do not include explicitly this term.

b) The thesis statement of the research is quite narrow in comparison to the presented enumeration of problems of the domain and the formulated research problem. The decision of limiting the benchmarking of the proposed solution to facial detection in the thesis is not clearly substantiated, as the author presents analysis and selection of numerous criteria for evaluating method in the dissertation work.

Analysis of the state of the art and existing solutions in the domain area is based on the extensive literature review and detailed characteristics of the technologies, existing in the area of financial services. The coverage of the research works includes reviewed literature, reports and analytical reviews of financial institutions. The author demonstrates ability to present the detailed information and to systematize and summarize it for further research. In general, the thesis demonstrates solid understanding of the state-of-the-art in the research area covering the most significant and current literature sources. The analytical part of the dissertation may serve as a valuable resource for future research on biometrics, behavioural methods, application of mobile technologies. The performed analysis enables author to highlight necessary characteristics and to identify the behavioural factors for the proposed solution. The technological aspects are analysed in line to the behavioural and usability factors which corresponds to the scope of requirements outlined in the Introduction and researched in the analytical part of the dissertation.

Proposed solution for investigation of the research questions is presented in the form of “method for behavioural biometrics authentication”. The mobile application and touchscreen usage- based methods for defining and detecting the states of anomaly, fraud and previous pattern are explored and selected for the proposed solution. The models for analysing patterns based on capturing touchscreen access data during the authentication process are explored, new features are identified for analysis, as compared to the existing research. The proposed classifiers, namely SVM, random forest and XGBoost are relevant to the data origin and the problem requirements. The proposed procedure of hyperparameter tuning improve performance of the proposed methods by enabling parameter optimisation, saving computational resources and increasing accuracy. The novel and original characteristics of the proposed model add value to the state of the art of identification and authentication area, and make contribution to the research.

Empirical analysis, data and experimental findings are presented and discussed in the corresponding chapter. The author provides detailed overview of a set of experiments, designed to explore features of the model. The experimental analysis proposes validation procedures for different characteristics of authentication based on different data types. The size and data quality of the databases (by number of users and swipes/taps characteristics) used for experimental analysis are relevant to the application of proposed computational methods. The existing databases are used for exploring the proposed model, as

well as own database was prepared for the empirical investigation purpose. It can be stated that the experimental analysis enabled to confirm, that the achieved accuracy of the behavioural authentication model surpasses published research results of the domain and the face detection methods, which ensures validation of the proposed approach. It can be observed that an aggregated description of the general strategy of the experimental research could more clearly highlight the interrelationship among the experiments and their role for characterizing performance of the proposed approach.

The Conclusion section summarizes the outcomes supporting and answering the research goals. The detailed argumentation of the achieved results is provided; however, the conclusion statements are not extensively illustrated by the experimental research numeric results for comparative evaluation to the benchmark values. However, the originality and novelty of the contribution, as described in the conclusion section, can be confirmed by the materials presented in the corresponding parts of the dissertation, therefore it can be stated that the pursued research goals were successfully achieved.

The dissertation author has prepared a monographic thesis consistently covering the selected topic. The **validation** of the major findings of the dissertation is demonstrated in five peer-reviewed publications. The publications are registered in the international scientific databases: three of the publications are included to ISI Web of Science, four of them – to Scopus. The publication types are: one journal article (ISI WoS), where the thesis author serves as the first author, 3 international conference proceedings, and one reviewed serial edition. The value of the publications and their content is relevant and fulfils requirements for validation of the doctoral dissertation.

The readability and language of the dissertation, as well as graphical and appendices' information is presented in high quality.

The dissertation contains original contribution of the proposed solutions, includes extensive response to the research questions and relevant validation of the findings. The overview of the results in the conclusion section provides substantiated answers to the research questions.

Summarizing all of above, the overall evaluation of the scientific level, presentation of the research results and novelty/originality of the thesis work above the state of the art, it can be stated that:

- 1) The research work prepared by Piotr Kałużny fully meets the general requirements of doctoral dissertation based on its structure, relevance, scope and content, and is valid for confirmation of **successful completion of the doctoral studies.**
- 2) The doctoral thesis demonstrates mature and complete research work on the selected topic and can be presented for the **public defence procedure for the award of the doctoral degree** in the field of Social sciences in the discipline of Economics and Finance;
- 3) The presented thesis succeeds to discuss and reach the research goals with the results outperforming the state of the art solutions in the area of financial domain. It demonstrates outstanding features of originality of the elaborated solution, its extensive theoretical substantiation and multi-perspective, machine learning based experimental validation, presenting findings emanating from the interdisciplinary approach and positioning of the research in the up-to-date innovative technological level of the financial market.

Based on these criteria I propose the doctoral dissertation authored by Piotr Kałużny “Behaviour-based user authentication for financial services” **for nominating the Doctoral Thesis of Distinction.**

Questions:

1. Did your research reveal major groups of problems of financial institutions where the behavioural approach could be most efficient for authentication?
2. Please reveal if the results of the solution proposed in the thesis may be applied for authentication purposes in general, and how does it specifically relate to the authentication in the transaction level? What accuracy level could be sufficient for this purpose.
3. The experimental analysis explored different aspects of authentication. Which of the proposed behavioural authentication factors and methods of accessing touch screen showed highest potential for financial services area, and, possibly may be adopted by banking institutions?

Reviewer



Dalia Krikščiūnienė