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SUMMARY OF THE DOCTORAL THESIS

Research on using artificial intelligence to improve auto and health insurance services

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Chapter 1 - General information related to the research and the structure of the doctoral thesis

The first chapter, entitled "General information related to the research and the structure of the doctoral thesis" is an introductory one, that aims to present the context and the objectives of the paper. This chapter illustrates the applicability of artificial intelligence (AI) in the insurance field and contextualizes the research approach by referencing the economic and technological position of the local insurance industry in both regional and global contexts. The importance, relevance, and necessity of the doctoral thesis topic are argued based on the international trend of integrating AI into insurance company processes, the benefits of integrating this technology, favorable economic projections regarding the profit AI can bring to this industry, the challenges faced by insurance companies in managing large data flows, and Romania's relatively unfavorable position concerning insurance premium revenues. The chapter also proposes the structure of secondary and specific objectives derived from the general objective, which is to research how can AI improve the services that are provided by insurance companies.

Specifically, the paper presents the research, design, implementation, and evaluation of two AI-based solutions aimed at streamlining the insurance claim management process for employees of companies in the local and international insurance industry. The first solution aims to improve the management of health insurance claims. The developed software solution seeks to automate the process of centralizing, verifying, and evaluating the documents needed to compensate for damages associated with this type of insurance. The second solution aims to optimize the management of claims in the auto insurance sector through a software application whose main functionalities include damage detection and the assessment of the associated accident costs. These two software solutions allow the improvement of services provided by insurance companies.

Several analyses support the validity of implementing AI solutions to optimize processes in insurance companies. A study conducted by Business Insider Intelligence on nine companies in the insurance industry suggests that AI-based technologies can lead to significant cost reductions (Nonninger, 2019). Additionally, Kumar et al. (2019) show that approximately half of the insurance companies investigated in an Everest Global study focus on implementing AI to optimize processes and improve customer experience. Similarly, Eckert & Osterrieder (2020) illustrate case studies where the use of AI technologies leads to the optimization of insurance company services. Along the same lines, an analysis by Eling et al. (2022) shows that the use of AI has a transformative impact on the insurance industry. Similarly, Jones & Sah (2023) present the impact of AI and big data techniques in the insurance industry, mentioning financial and operational benefits. Wilkinson et al. (2024) enumerate operational efficiency and financial gains as benefits of using AI technologies in the insurance field. Moreover, Khalisa (2024) illustrates that improving insurance services through digital technologies like AI brings benefits not only to insurance companies but also to their employees and clients.

The fulfillment of the doctoral thesis objective, as stated at the beginning of the first chapter, is documented through seven main chapters that present the research and development activities carried out to achieve the proposed objective. Each chapter presents relevant and current aspects regarding the insurance industry, as well as how applications utilizing artificial intelligence can be implemented in companies operating in this industry.

Chapter 2 The current state of research on the use of artificial intelligence in the insurance industry

The second chapter, entitled "The current state of research on the use of artificial intelligence in the insurance industry" provides information about artificial intelligence and its application in the insurance sector. The chapter presents the theoretical and technical foundations of the doctoral thesis. The first section defines AI and outlines the main characteristics of the types of technologies encompassed by this term. The second and third sections focus on existing research regarding the use of two AI technologies in the insurance industry: natural language processing (NLP) and computer vision (CV). The final section analyzes existing commercial systems that use AI to streamline processes in the auto and health insurance industries. Consequently, Chapter Two contributes to the presentation of current knowledge by analyzing AI technologies, in order to identify solutions that can address issues in the insurance industry, as well as by examining academic and commercial efforts to implement AI in the insurance industry on a global scale.

The main objective of this chapter was to analyze the current state of AI technologies and to identify technologies that can be used to address real operational problems in the insurance industry. Building on this objective, three secondary objectives were further defined. The first was to conduct an analysis of existing technologies for natural language processing and computer vision. The second objective was to analyze the current state of research on NLP and CV technologies in the insurance industry. The third secondary objective involved analyzing at least eight existing commercial systems that use NLP or CV in the insurance industry.

To achieve these secondary objectives, a series of studies were conducted, as follows. First, a review of the specialized literature on natural language processing and computer vision technologies was carried out. This research aimed to fulfill the first secondary objective, specifically analyzing existing technologies for natural language and image processing. The second study focused on fulfilling the second secondary objective, which involved analyzing the specialized literature on academic efforts to implement NLP and CV technologies in the insurance industry. The third study, corresponding to the third secondary objective, focused on analyzing public information regarding existing commercial systems that use NLP or CV in the insurance industry.

Together, these analyses allowed for the achievement of the three secondary objectives and the overall objective of this chapter. The research conducted, as described above, enabled an analysis of the possibilities of using AI in insurance, ranging from systems based on machine learning (ML) algorithms to more complex systems based on deep learning (DL). It is worth mentioning that an emerging trend toward generative multimodal AI systems, which integrate NLP, CV, and other techniques, was identified. However, the development of such systems requires a mature industry with reliable DL or ML systems adapted to the local market, which is currently lacking in the local industry. Consequently, chapter two provided the rationale for the research and development approach presented in the following chapters.

Chapter 3 - Insurance companies and their profitability and technological systems

The third chapter, entitled "Insurance companies and their profitability and technological systems" provides an overview of the economic and technical structure of insurance companies. The primary focus of this chapter is to present the structure and operational functioning of insurance companies. The first section offers general information on the operating principles and organizational structure of insurance companies. The second section focuses on analyzing the profitability and expense structure within the insurance sector, with particular emphasis on health and auto insurance. Finally, the last section examines the information systems used in the insurance industry and the challenges they present, with a focus on the systems employed in the local market and the automation trends that have supported and motivated the current research effort. This chapter contributes to existing knowledge by conducting analyses within the insurance industry to present the economic and technological structure of existing economic operators.

The general objective of this chapter was to analyze the insurance industry at both the international and local levels to identify problems that can be addressed through the development of information systems. Within this chapter, one of the secondary objectives derived from the previously mentioned general objective was achieved, specifically the analysis of the functional and economic structure of the insurance industry by referencing existing international literature and accessible national data. This secondary objective was met through the study of specialized literature and public information regarding the functional and economic structure of the insurance industry.

In terms of results, it is worth mentioning the illustration of underwriting and claims processing procedures, the analysis of revenue and expense structures, and the identification of macroeconomic and technical factors affecting the profitability of insurance companies. Figure 3.1 illustrates the market share of major economic players in the local industry as part of the analyses conducted in this chapter.

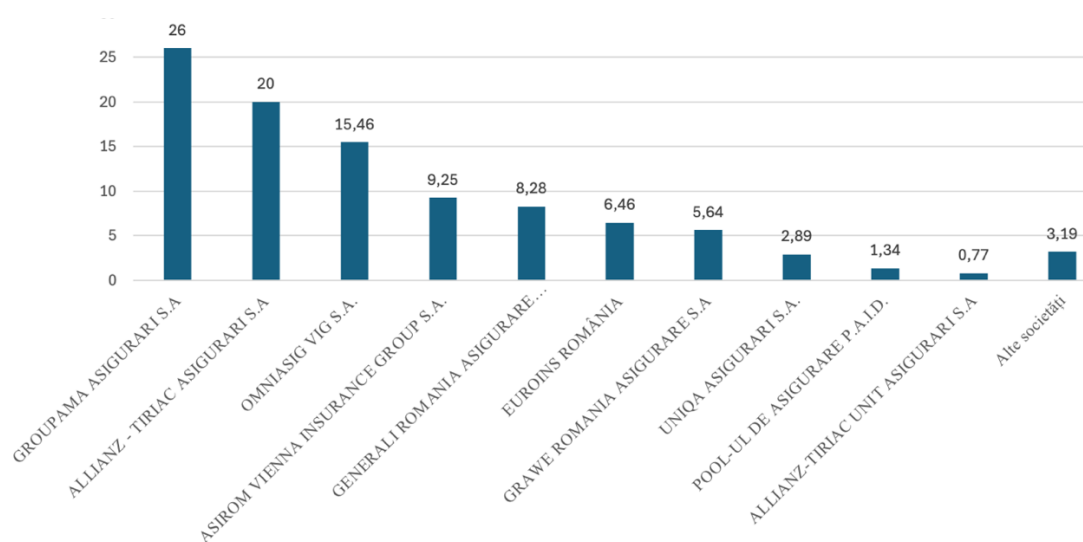


Figure 3.1. Market share of insurance companies operating in Romania, in the first nine months of 2023 (percentages).

Source: Adapted from Autoritatea de Supraveghere Financiară. (2023). *Evoluția Pieței de Asigurări*. Accessed on March 18, 2024, Available at: <https://www.asfromania.ro/uploads/articole/attachments/65c0f91a950a5260439780.pdf> pp. 17.

Chapter 4 - Research for identifying requirements for developing software solutions and presenting possible project management methodologies

Chapter four, entitled " Research for identifying requirements for developing software solutions and presenting possible project management methodologies" focuses on identifying specific problems faced by local insurance companies, as well as defining potential management methodologies for handling the implementation projects of the targeted software solutions. This chapter has a dual purpose. Firstly, it presents the results of the research conducted to identify the requirements necessary for developing the targeted applications. Secondly, the chapter introduces the results of the analyses carried out to select the appropriate management methodology for managing the implementation projects of the targeted applications. Thus, in the first two sections of this chapter, four empirical studies are introduced, that were conducted to identify the problems and opportunities that can be addressed through the development of information systems utilizing AI. The final section proposes a theoretical presentation of possible project management methodologies for implementing software applications. Together, the sections of this chapter served as the starting point for designing the information systems developed and presented in this work. The chapter contributes to current knowledge through research conducted within the local insurance industry, providing a systematic analysis of the perceptions of clients and the personnel of existing economic operators.

The general objective of this chapter was to analyze the insurance industry at both international and local levels to identify problems that can be addressed through the development of information systems utilizing artificial intelligence. Within this chapter, two secondary objectives derived from the aforementioned general objective were achieved. The first secondary objective was to conduct at least one study using data from the health insurance sector in Romania to identify opportunities for developing automated systems. To achieve this objective, both a qualitative primary research based on in-depth interviews with managers from insurance companies and public documents, as well as a quantitative primary research based on a survey regarding potential users' perceptions of a conversational agent system within the insurance system, were conducted. The second secondary objective achieved involved conducting at least one study using data from the auto insurance sector in Romania to identify opportunities for automation through AI technologies. In this regard, both a quantitative primary research concerning the problems encountered by employees of insurance companies and a quantitative primary research on the problems faced by insurance company clients, both based on the questionnaire method, were carried out.

In terms of results, the investigations conducted illustrated that, regarding the structure and participants in the health insurance segment, the research and development effort is most appropriately directed towards developing an AI solution integrated with existing insurance systems, without a new interface for interaction with the insurance company policyholders. Regarding the auto insurance segment, an opportunity was identified to develop a solution that would enable the streamlining of the relationship between insurance company representatives and their clients through an automated system for processing claims in the event of a car accident. Last but not least, chapter four introduced a series of management methodologies for translating the research results into functional requirements and action plans for implementing software solutions.

Chapter 5 - Development and validation of the IT solution for improving health insurance services

Chapter five, entitled "Development and validation of the IT solution for improving health insurance services" presents the various aspects involved in the design, implementation, and validation of the software solution developed for the health insurance sector. The chapter begins by illustrating the functional requirements and architecture of the solution, which was defined as a response to the problem of reducing insurance companies' costs through automation.

Following this, the next section introduces the application that resulted from the implementation process. The subsequent sections detail the methodology and results of the testing and validation process for the application. Specifically, the final sections of the chapter focus on the technical evaluation and economic validation of the developed application. Figure 5.1 illustrates a central component of the developed application.

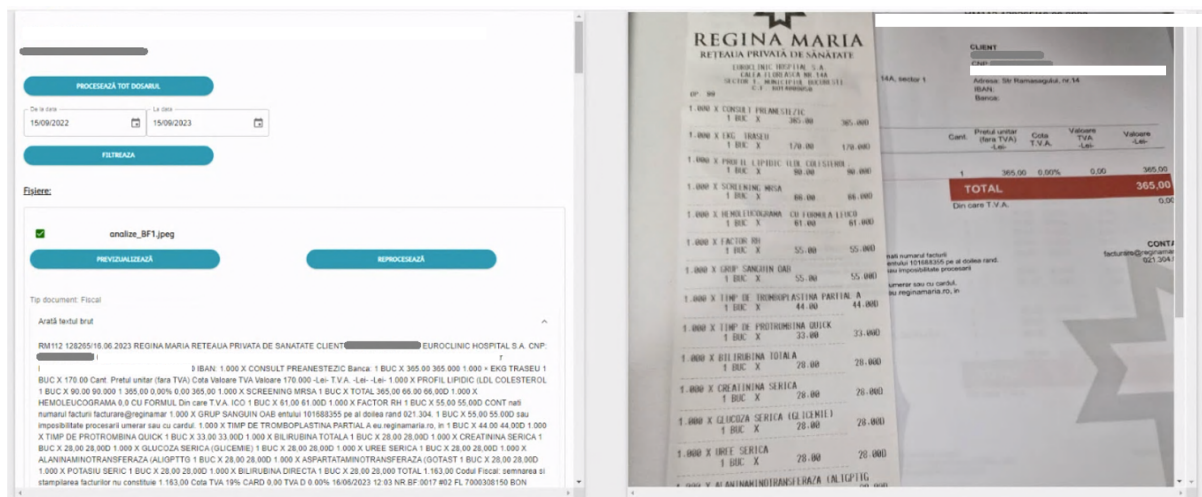


Figure 5.1. Interface for extracting text from documents attached by clients via OCR from the developed health insurance application.

The system's capability to extract information from documents issued by clinics demonstrates satisfactory performance. Additionally, the functionality of the system in classifying the type of service consumed by a client based on the extracted information also shows satisfactory performance. The five-year economic projection indicates that the investment will be recovered after three years of use, with the results obtained demonstrating the reliability and validity of the developed system. Furthermore, the chapter outlines potential directions for improving the application, based on the results observed during implementation.

This illustrates the fulfillment of the specific objective, namely the implementation of an AI system aimed at streamlining the health insurance management process for insurance companies, by achieving three specific objectives: designing, developing, and evaluating the system. Moreover, this chapter highlights the contributions of the present work to the Romanian entrepreneurial environment, through the development of an innovative AI-based system for optimizing processes in the health insurance sector, as well as its successful implementation within a local insurance company.

Chapter 6 - Development and validation of the IT solution for improving auto insurance services

The sixth chapter, entitled "Development and validation of the IT solution for improving auto insurance services" explores the design, implementation, and validation of the software solution developed for the auto insurance sector. The first section of this chapter details the functional requirements and architecture of the solution, which was designed to address the challenge of reducing insurance companies' costs through automation.

The following section introduces the application that resulted from the implementation process. Subsequent sections present the methodology and results of the testing and validation processes for the system. Similar to the previous chapter, this section also covers the technical evaluation and economic validation of the developed application. Figure 6.1 illustrates a central component of the developed application.



Figure 6.8. Screen for viewing and editing damages in the developed auto insurance application

To conclude, the system's capabilities for predicting vehicle prices based on their characteristics and detecting vehicle damage from images are satisfactory. However, the AI functionalities related to segmenting vehicle components from images and detecting the vehicle's model, make, and year of manufacture exhibit excellent performance. The system's user interface scores highly on usability, and the economic validation process suggests that the developed solution can provide both direct benefits (e.g., reduction in operational costs) and indirect benefits (e.g., increased customer satisfaction).

The results presented in this chapter demonstrate the reliability and validity of the developed system and confirm the achievement of the specific objective of implementing an AI system aimed at streamlining the management of auto insurance processes by insurance companies. This was accomplished by meeting three specific objectives: designing, developing, and evaluating the system.

In terms of contributions to the entrepreneurial and scientific communities, this chapter highlights the development of an innovative AI system for optimizing processes in the auto insurance sector. It also underscores the validation of the system with potential users, the implementation of multiple AI models, and the publication of a new, annotated open-source dataset to facilitate scientific experiments.

Chapter 7 - Conclusions, contributions, and future research

In conclusion, the doctoral thesis detailed the research, design, development, and testing of two AI-based solutions aimed at improving the management of insurance claims by insurance companies. The first solution, already implemented within an insurance company, enhances the management of health insurance claims. The second solution, validated by users, is intended for managing auto insurance claims. Together, these software solutions demonstrate the potential for AI to improve services in both auto and health insurance sectors.

The final chapter outlines the conclusions of the doctoral thesis, original technical and economic contributions in relation to existing knowledge, and future research directions. It presents the conclusions of each chapter, lists the contributions made, and discusses four primary future research directions. A significant portion of these contributions has been documented and communicated through a series of seven scientific publications, ensuring broad dissemination of results and impact within the academic and professional communities.

During the research undertaken in order to write the present paper, a series of contributions were generated, in terms of knowledge and economic results. The major contributions are outlined in the list below.

- Analysis of Artificial Intelligence Technologies: Examination of AI technologies to identify solutions that can address problems in the insurance industry.
- Evaluation of Academic and Commercial AI Efforts: Analysis of academic and commercial efforts to implement AI within the insurance industry at an international level.
- Research on Local Insurance Industry: Conducted research within the local insurance industry to systematically analyze the perceptions of clients and staff of existing economic operators.
- Development of an Innovative AI System for Health Insurance: Creation of an innovative AI system designed to optimize processes in the health insurance sector.
- Successful Implementation of the Health Insurance System: Effective implementation of the AI solution aimed at improving processes in the health insurance sector within a local insurance company.
- Development and Validation of an Integrated AI System for Auto Insurance: Development of an innovative integrated AI system for optimizing processes in the auto insurance sector, with validation involving potential users.
- Implementation of Multiple AI Models: Deployment of multiple AI models tailored to the local market in Romania for automatic image processing of vehicles and prediction of repair costs in the event of an accident.
- Publication of a New Annotated Dataset: Release of a new open-source annotated dataset to facilitate scientific experiments related to the use of AI for automatic image processing.

Thus, the doctoral thesis not only made significant contributions to advancing knowledge in the insurance field, but has also demonstrated its relevance and direct impact on improving practices and economic efficiency within the insurance industry. These contributions mark an important step toward a more informed and sustainable approach to complex problems in the insurance sector, fostering innovation and continuous adaptation to modern market demands.

Published articles

A. ISI Articles

Dutulescu, A., Catruna, A., Ruseti, S., Iorga, D., **Ghita, V.**, Neagu, L. M., & Dascalu, M. (2023). Car Price Quotes Driven by Data-Comprehensive Predictions Grounded in Deep Learning Techniques. *Electronics*, 12(14), 3083. WOS:001038183200001

Catruna, A., Betiu, P., Tertes, E., **Ghita, V.**, Radoi, E., Mocanu, I., & Dascalu, M. (2023). Car Full View Dataset: Fine-Grained Predictions of Car Orientation from Images. *Electronics*, 12(24), 4947. WOS:001130998100001

B. Articles published in other journals or volumes

Dutulescu, A., Iamandei, M., Neagu, L. M., Ruseti, S., **Ghita, V.**, & Dascalu, M. (2023, May). What is the Price of Your Used Car? Automated Predictions using XGBoost and Neural Networks. 24th International Conference on Control Systems and Computer Science (CSCS) (pp. 418-425). IEEE.

Ghita, V., Iorga, D., Neagu, L. M., Dascalu, M., & Militaru, G. (2023, March). AI for Car Damage Detection and Repair Price Estimation in Insurance: Market Research and Novel Solution. *International Conference on Business Excellence* (pp. 167-179). Cham: Springer Nature Switzerland.

Iorga, D., Dutulescu, A., Catruna, A., **Ghita, V.**, Neagu, L.-M., Dascalu, M., Militaru, G., (2023) A Pilot Usability Assessment of an AI Platform for Car Price Estimates. *The 2023 International Conference on Human-Computer Interaction*.

Ghita, V., Iorga, D., Dutulescu A., Dascalu, M., & Militaru G. (2023). "Lemon" perceptions? A comparative analysis of second-hand cars' prices in Romania and Germany. *International Conference of Management and Industrial Engineering* (Vol. 11, pp. 397-400) Niculescu Publishing House.

Ghita, V., & Militaru, G. (2021). The design of an application that automates client access to health insurance using artificial intelligence. *International Conference on Management and Industrial Engineering* (No. 10, pp. 147-160). Niculescu Publishing House.

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