Fortaleza City Hall Strategic Planning based on Data Analysis and Forecasting

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Abstract. *This paper presents the Big Data Fortaleza platform, which uses Big Data and Machine Learning for providing data analysis and prediction. The platform aims to assist in the strategic planning of solutions for the sustainable urban development of Fortaleza, in line with the activities of the Fortaleza Planning Institute (IPLANFOR). The challenge initially addressed is Early Childhood, once intelligent data management can significantly contribute to decision-making aimed at improving child development. Several exploratory and predictive analyses have been conducted to address critical issues in this domain, identified through discussions with several stakeholders from Fortaleza City Hall.*

Resumo. *Este artigo apresenta a plataforma Big Data Fortaleza que utiliza técnicas de Big Data e Machine Learning para análise de dados e predição. Seu objetivo é auxiliar no planejamento estratégico de soluções para o desenvolvimento urbano sustentável de Fortaleza, em consonância com as atividades do Instituto de Planejamento de Fortaleza (IPLANFOR). O desafio inicialmente abordado é relacionado à Primeira Infância, uma vez que a gestão inteligente de dados contribui significativamente para a tomada de decisões que visam melhorar o desenvolvimento infantil. Até o momento, diversas análises exploratórias e preditivas foram conduzidas para abordar questões essenciais nesse domínio.*

1. Introduction

Smart Cities emerged aiming to evolve cities to the future in which citizens' well-being is prioritized, and industry and urban planning are evaluated from a sustainable perspective [Sánchez-Corcuera et al. 2019]. From this perspective, technologies such as Big Data, Internet of Things (IoT), Cloud Computing, Artificial Intelligence, Software Engineering and Mobile Computing are allies in several Smart City scenarios.

Initially, the city of Fortaleza established a comprehensive urban plan designed to harmonize territorial development with socioeconomic advancement. This plan encompasses a strategic framework with objectives segmented into short, medium, and long-term phases, projecting up to the year 2040. Furthermore, it seeks to foster multifaceted discourse concerning urban development, engaging diverse perspectives, sectors, geographical regions, and governmental levels. Fortaleza 2040[1] presents challenges to overcome low qualifications, youth vulnerability, poverty, and social inequality as well as educational backwardness.

Given these challenges, data collection and analysis as well as machine learning techniques are essential for diagnosing and supporting the decisions of city managers. By analyzing the available data intelligently, it is possible, for example, to improve the quality of services offered to citizens and to anticipate the impact of changes in urban infrastructure.

Thus, this paper presents the Big Data Fortaleza platform, which uses Big Data and Machine Learning techniques for providing, respectively, data analysis and forecasting, as well as cloud computing and software engineering. The platform emerged to support the activities of the mayor, vice-mayor, and secretaries to solve Fortaleza's demands and to assist them in the strategic planning of solutions for the sustainable urban development of Fortaleza city, in line with the activities of the Fortaleza Planning Institute (IPLANFOR)[2]

The challenge initially addressed was Early Childhood, children between the ages of zero and six years old, once intelligent data management can significantly contribute to decision-making aimed at improving child development. The challenges faced in Early Childhood encompasses cross-sectoral areas of action, so we have first focused on children between the ages of zero and four years old and actions in health, education, human rights, and social development. In education, public managers must guarantee access to nurseries and schools for early childhood education. In health, it is crucial to take care of pregnant women by attending prenatal appointments and ensuring that the child receives care after birth, such as appointments and vaccinations. In human rights and social development, it is essential to identify families in a situation of socio-economic vulnerability or homelessness and offer support through social benefits, intending to reduce inequalities in access to goods and services that meet children's rights.

2. BigData Fortaleza Platform

As previously discussed, the BigData Fortaleza platform was designed to assist decision-making in different contexts of the city. Therefore, it was necessary to build a platform capable of adapting to the different data types that each challenge requires. The platform architecture follows the Medallion architecture and was implemented using Amazon AWS services such as S3, Glue, Athena among others [Saxena et al. 2023].

2.1. Workflow

The platform workflow has as its central point the challenge defined by the managers of Fortaleza City Hall (PMF – from Portuguese "Prefeitura Municipal de Fortaleza").

[1]Fortaleza 2040 website: fortaleza2040.fortaleza.ce.gov.br/site/.

[2]Iplanfor website: iplanfor.fortaleza.ce.gov.br.

These challenges can be related to initiatives to reduce social inequalities, as outlined in the Fortaleza 2040 plan. Data scientists then begin to understand the challenge domain, identifying issues in collaboration with PMF stakeholders (for example, using structured meetings) and defining the data products as well as the process of acquiring, processing and analyzing data.

The process begins with the definition of the challenge by public managers and follows with the registration of this challenge on the platform. This registration is crucial for monitoring the activities performed by the data scientists, such as understanding the context, identifying the strategic questions, defining the data products, processing and analyzing data, and validating the answers with Big Data. At the end of the process, the access profiles for the functionalities and the user groups for viewing each analysis are defined, and managers can analyze the data products.

2.2. Platform Development

The platform development follows software engineering principles, including the Scrum methodology, requirements engineering, continuous integration, software testing and validation, and user experience and interface. The platform was developed using the following technologies: React, Spring Boot, Mongo DB, and Amazon Web Services (AWS). Several tests were also conducted using the OWASP ZAP framework to ensure the platform security. In addition, the Brazilian General Personal Data Protection Law (LGPD) was followed throughout the process. Figure 1 shows the platform home page (A) and an example of the system's monitoring panel, where managers can customize and add analytics. (B).

Figure 1. (A) Home page of the BigData Fortaleza platform. (B) Example of analytics on the Early Childhood challenge

3. Platform Impacts and Results

The first challenge of the BigData Fortaleza platform was the "Demand for Daycare Vacancies". Thus, the team launched initiatives to achieve tangible results in the project first six months (from July to December, 2022). During the first quarter of 2023, efforts were directed toward other challenges related to personalized care for pregnant women and vaccination in daycare centers.

The map in Figure 2 (A) shows the current number of pregnant women per neighborhood in Fortaleza. The number of pregnant women per neighborhood can help with future demands for places in daycare centers and personalized health care for pregnant women.

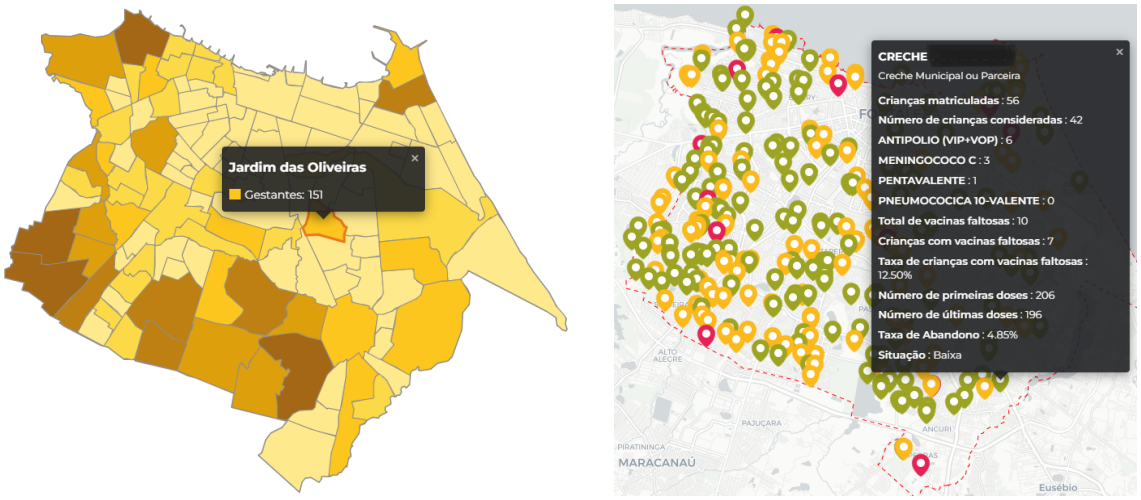

Figure 2. (A) Choropleth map of pregnant women by neighborhood. (B) Geographical Map with Daycare Centers and Missing Vaccination in Children.

The map in Figure 2 (B) shows the integration of education and health data. Each nursery school shown in the map provides information on the number of children enrolled and how many children have missing vaccinations, supporting Fortaleza City Hall in making personalized public policies, such as vaccination campaigns in nurseries.

4. Final Remarks and Acknowledgments

Going beyond conventional analysis platforms, the BigData Fortaleza[3] platform focuses on data visualizations and forecasts to anticipate future demands of the population. PMF managers can obtain customized information to help their decisions on public policies that will allow them to analyze current scenarios accurately and predict future demands more reliably.

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