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Research Article

How Software Quality May End World Hunger

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Abstract

Software Quality could end world hunger by producing better quality software, as the total cost generated by poor software quality in the U.S. amounted to $2.08 trillion in 2020, while the director of the United Nations' World Food Program stated in 2021 that it would take approximately $40 billion a year to end world hunger by 2030. As the cost of food is the leading cause of 828 million people sleeping hungry around the globe, Software Quality can significantly contribute in several ways to its reduction by producing more profitable software, so that companies may be able to invest the surplus resources in other areas such as food production, as well as in the development of specific software that reduces overall losses in planting, harvesting, transporting and storing food, contributing to the reduction of its final market price, which in turn will allow the access of a greater number of people to the nutrients necessary for their day-to-day sustenance. Thus, there is a need to gather the initiatives presented in this work to allow the global quantification of losses, enabling rapid decision making for their reduction, as well as improving the functionality of these software programs with the use of artificial intelligence techniques.

Keywords

Software Quality, World Hunger, Artificial Intelligence

1. Introduction

Software Quality could end the world's hunger by producing better quality software, because according to the study *The Cost of Poor Software Quality In the US: A 2020 Report* [1], prepared by the Consortium for Information & Software Quality (CISQ), it was determined that the total cost of poor software quality (*CPSQ*) in the U.S. was $2.08 trillion in 2020, as shown in Figure 1.

In July 2021, the Executive Director of the United Nations World Food Program (UN WFP), David Beasley, stated that approximately $40 billion a year would be needed to end world hunger by 2030 [2], while International Monetary Fund (IMF) Director Kristalina Georgieva assured in 2022 that $50 billion is needed to end world hunger [3], that is, if quality software is produced, it would be possible to end world hunger more than 40 (forty) times.

Although the whole problem has multiple causes [4], the cost of food is the main cause of 828 million people sleeping hungry every night, according to the World Food Program [5] that can be reduced through increased supply, as long as the surplus resources from improving Software Quality are invested in the creation of agricultural areas such as the creation of an artificial river created to irrigate the desert sands near the Nile Delta whose estimated cost is US$ 5.25 billion [6].

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Figure 1. *Total CPSQ in the US (2020) [1].*

2. Future Trends

Although software vendors spend 30% to 50% of the development budget on detecting and correcting defects [7], the costs of non-Software Quality tend to grow, especially due to technical debt [1], which can be defined as the cost arising from the delivery of immature artifacts that bring short-term benefits in terms of productivity and project costs, but that they will charge high interest later [8].

Software Quality Improvement involves Software Quality Management (SQM), which seeks to ensure that the product meets the quality standards expected by the customer through testing and auditing to reveal and correct errors prior to its release or delivery, encouraging quality culture throughout the company [9-11].

The creation of a culture of Software Quality goes through the professional qualification that can be obtained by licensing, professional certification and academic training [12] in schools that appropriate new technologies, in particular, artificial intelligence.

Although global food production will be sufficient to meet demand in the coming decades, the world still faces a severe food crisis that is as dangerous to the lives of millions of people today as in the past [13].

Hunger tends to grow [14] for various reasons such as the growth of poverty associated with population growth [15], the water crisis characterized by the decline of surface and groundwater available for irrigation [16] and the phosphate crisis, as global reserves of phosphorus, used as phosphate in fertilizers, are depleting, which can result in famine due to poor harvests [17].

Although the private sector has the possibility to lead the fight against world hunger, traditional models that deal with the treatment and prevention of malnutrition from the perspective of corporate social responsibility are failing to solve the problem [18]. Corporate Social Responsibility (CSR) is a management concept in which companies aggregate social and environmental concerns into their business operations and interactions with their stakeholders, which is the way in which a company achieves a balance of economic, environmental and social needs (*Triple-Bottom-Line-Approach*) while meeting the expectations of its shareholders, that is, there is a clear difference between CSR and charity [19].

Sustainably feeding 10 billion people by 2050 is possible, but it requires significant innovation and investment from the public and private sectors [20], as it involves the following issues that can be favored, such as the use of artificial intelligence:

1. Protein intake;
2. Food distribution;
3. Loss of food;
4. Food waste;
5. Environmental degradation;
6. Water crisis;
7. Biofuels.

3. Software Quality and Artificial Intelligence

Artificial intelligence (AI), which can be defined as the science and engineering of making intelligent computer programs [21], has much to contribute to software quality [22] in activities such as writing software through tools with GitHub Copilot [23], software testing such as Ranorex Studio and Testim [24, 25] and as a cognitive services platform for automating business processes such as Watson [26].

For the increase in protein consumption by the growing population, it is possible to adopt artificial selection with the support of artificial intelligence, reducing errors and optimizing the process of choosing animals that will reproduce based on their genetic heritage [27].

In relation to food production, especially in the production of grains such as rice, corn and wheat, artificial intelligence can contribute to the increase in the accuracy of climate simulation software, in which the variables represent a large number of characteristics of the land surface and atmosphere for an arable area, being distributed by a series of cores of a supercomputer that performs the simulation [28], indicating the best time for planting and harvesting, increasing productivity and reducing its final cost, for example, planting cereals in winter increased the productivity of the farmer Agricultural Research and Rural Extension Company of the state of Santa Catarina [29].

Artificial intelligence can also assist in the design of new machines, such as combine harvesters, to reduce the grain loss that is associated with the regulation of the harvester, the height of the cutting platform and the speed of displacement. The recommended working speed for a combine harvester is determined as a function of crop productivity due to its ability

to separate the biomass that is harvested along with the grain. In the corn harvest, for example, the working speed varies from 4 km/ha to 6 km/h, that is, increasing the speed implies changing the work capacity of the harvester, resulting in losses greater than 1.5 bags/ha [30].

In this sense, machine builders are adopting an advanced collaborative design solution known as intelligent performance engineering (IPE) that utilizes digital simulation and analysis tools that allow them to assess the impacts of design choices, helping equipment manufacturers manage the complexity of building the next generation of machines through comprehensive digital twin technology [31].

The demand for automated agriculture is growing in the world as it is increasingly difficult to find qualified personnel to operate a combine harvester, for example, resulting in the development of autonomous harvesters for precision agriculture that can be improved with the use of artificial intelligence techniques. For example, to decrease the workload and increase efficiency in blueberry harvesting, a stand-alone harvester has been developed that separates the berries and places them in plastic bins, which are automatically replaced when filled [32].

Artificial intelligence can contribute to the development of better logistics software for the transportation of the crop that in Brazil is mostly road, representing 61.1% of the Brazilian transport matrix, according to the National Transport Confederation [33], which increases the cost of grains and contributes to the losses that, in 2020, were 1.58 million tons of soybeans and 1.34 million tons of corn, according to agronomist Thiago Guilherme Péra, coordinator of the Research and Extension Group in Agroindustrial Logistics of the Luiz de Queiroz School of Agriculture of the University of São Paulo [34].

In this sense, artificial intelligence can also assist in the design of new trailer and semitrailer bulk carriers that reduce grain loss, such as the Randon Company's standard bulk trailer line [35], which uses sealed side panels manufactured in a flexible component compound to avoid permanent deformation and ensure less grain loss.

For food preservation, gas permeability limits the shelf life of packaged products, mainly in Ready for Consumption Meals, which must be stored for up to 3 (three) years for military use [36] and up to 5 (five) years for use in space missions [37]. Simulation software for the development of new packaging and artificial intelligence can help improve their accuracy and reduce their development life cycle, contributing to the reduction of food losses and negative environmental impacts.

Figure 2 shows the percentages of food losses from post-harvest to distribution, as food loss, in addition to the ethical side of waste that promotes hunger, causes financial losses and environmental depletion of agricultural resources.

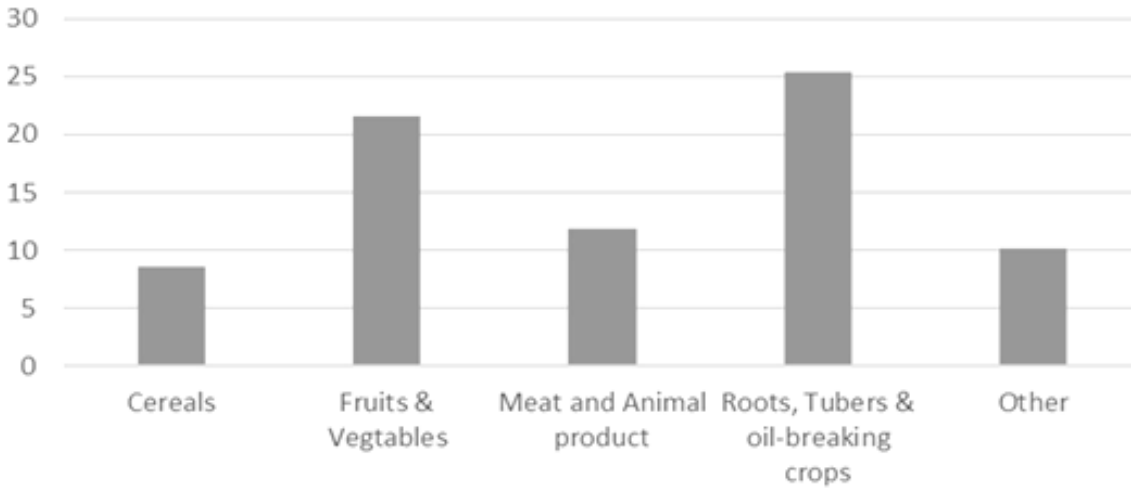

Figure 2. *Percentages of food loss along the supply chain [13].*

Regarding the consumption of biofuels, in Brazil, 27% (twenty-seven percent) of anhydrous alcohol is added to gasoline, that is, in 2020, 35.6 billion liters of anhydrous alcohol added to gasoline were consumed (ANP - National Agency of Petroleum, Natural Gas and Biofuels - https://www.gov.br/anp/pt-br), requiring a planting area of more than 64,000 km^2, which is equivalent to the sum of the areas of Switzerland (41,277 km^2) and Slovenia (20,273 km^2) combined that could be used to grow food instead of sugarcane, but the correction and optimization of the location of supply points with the use of artificial intelligence can accelerate the use of electric vehicle fleets [38], reducing the demand for biofuels.

4. Proposed Solutions

As world hunger is a problem of multiple causes, it requires solutions on a case-by-case basis, that is, the sum of initiatives

for the solution of simple issues results in great savings by avoiding the waste of fresh or processed food, contributing to the conservation of natural resources and reducing the accumulation of garbage in large urban centers, as follows:

a) DTU: the global food industry uses preventive microbiology to improve the safety and quality of its products, avoiding the waste of fresh and processed foods, through software based on mathematical and statistical modeling to predict the behavior of microorganisms such as the Food Spoilage and Safety Predictor [39], developed by Paw Dalgaard, professor at the Technical University of Denmark – DTU, which is distributed free of charge.
b) UNICAMP: although drying is an ancestral food preservation method that consists of reducing the moisture content of a food product to reduce microbiological activity, it still generates losses resulting from processing failures, requiring simulation programs such as the one developed by Kil Jin Brandini Park at the State University of Campinas [40].
c) PackID: presents a solution for the real-time monitoring of the humidity and temperature of fresh and frozen food in all stages of the production process, from receipt to shipment and transport in trunks of trucks and containers through GPRS (General Packet Radio Service) sensors, with international reach, allowing the sending of reports and notifications about incidents in real time that enable quick decisions to reduce the loss and cost of food [41].
d) Sigmais: presents an IoT (Internet of Things) solution to improve food quality control autonomously by monitoring the temperature and humidity of the place intended for conservation, as well as monitoring with alerts of opening and closing doors of cold rooms and in case of equipment failures, enabling real-time decision-making to reduce product loss [42].
e) Suflex: presents an IoT (Internet of Things) solution for the management of ready-made food validities, since operational errors are recurrent in restaurants and in industrial and hospital kitchens, including in special diets for people with food allergies and the sick, due to failures and omissions in the filling of labels, allowing real-time control of which product will win to reduce losses [43].
f) Toledo: Brazilian supermarkets can use a barcode that alerts the consumer if the product is expired at the time of passing through the cash register and sends emails to the manager warning which goods are close to expiration. However, the system is only used in heavy goods in the store because only the scales of the Toledo brand [44] have the software embedded. As the EAN 13 (European Article Number) barcode system does not support validity information, a new code based on the GS1-128 system [45] used for logistics and product traceability has been created.
g) Loyal: Standard operating procedures (SOPs) are a set of instructions that detail the operations to be carried out in all sectors of the food industry. Thus, each person knows exactly what they must do, ensuring that the task will be performed according to what has been prescribed, such as cleaning and disinfecting equipment, as well as the selection of raw materials, the standardization of recipes, and the preservation and transportation of food, minimizing the risks to food safety. In this sense, the collection and evaluation of information confirms whether or not control measures can mitigate risks or if they need to be updated. Quality management software enables the optimization of the processes of companies in the food segment, allowing them to manage the tasks of the quality system and ensuring that they are carried out correctly and in the expected time [46].

5. Conclusion

Software Quality can contribute in various ways to reducing world hunger by enabling the production of more profitable software for companies that can invest surplus resources in other areas such as food production, as well as in the production of specific software that reduces losses in planting, harvesting, transporting and storing food, contributing to the reduction of its final price that will allow the access of a greater number of people to the nutrients necessary for their sustenance, including helping the poorest countries to expand their assistance programs to combat hunger.

Therefore, there is a need to bring together the initiatives presented with many others available in the market to allow the global quantification of losses, enabling rapid decision making for their reduction, as well as the improvement of these software programs with the use of artificial intelligence techniques.

There is a need to bring together the initiatives for the use of artificial intelligence presented with many others available in the market, especially those developed by *startups* to allow the global quantification of food losses, enabling rapid decision-making for their reduction, as well as the improvement of software and its rapid implementation, because hunger is urgent.

With this work, it is hoped to provide more elements for the discussion on *How AI Could Feed The World's Hungry While Sustaining The Planet* [47] through practical examples and solutions that should be analyzed in greater depth in search of effectiveness in solving this problem that directly or indirectly affects each of us human beings.

Abbreviations

AI	Artificial Intelligence
CISQ	Consortium for Information & Software Quality
CSR	Corporate Social Responsibility
CSPQ	Cost of Poor Software Quality
EAN	European Article Number

GPRS	General Packet Radio Service
IPE	Intelligent Performance Management
IMF	International Monetary Fund
IoT	Internet of Things
ANP	National Agency of Petroleum, National Gas and Biofuels
SQM	Software Quality Management
SOPs	Standard Operating Procedures
UNICAMP	State University of Campinas
DTU	Technical University of Denmark
UN	United Nations
UN WFP	United Nations World Food Program

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Gilberto Joao Pavani: Writing – original draft, Writing – review & editing

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Data Availability Statement

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Fields

Gilberto Joao Pavani: Computer Science, Materials Science, Occupational safety

Lucas Ferreira Pavani: Software Engineering