Merging Computer Science Curriculum At the University of Virginia With The Industry Standard For Programmers
Data Analytics and Its Role in Humanitarian Food Aid

A Thesis
in STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia

By
James Zhu

October 18, 2022

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisors
Kent Wayland, Department of Engineering and Society
Briana Morrison, Department of Computer Science

Introduction

General Research Problem: Creating Systems of Infrastructure to Assist World Hunger

How can we create infrastructure to distribute food and resources to areas of the world suffering from food shortages and malnutrition? In the last two decades, there has been a massive increase in agricultural production with the advancements in technology and the economic growth associated with it. It is commonly said that there is enough food produced to feed all 7.7 million people who live on Earth - yet world hunger still remains a tremendous problem (United Nations, 2019). Around 828 million people (~10% of human population) across the world are chronically undernourished with around 44 countries who have severe food insecurity problems on the Global Hunger Index (Global Hunger Index, 2022).

Access to food is a necessity to survival and a basic human need. Children who are malnourished encounter a myriad of health issues such as impared brain development and can develop irreversible physical/mental disabilities (Palupi, 2013, 47). These health complications not only affect their lives but have the capability to carry over to future generations and threaten their quality of life as well (Palupi, 2013, 47). More severely, a lack of access to food has contributed to the deaths of around 3.1 million children every year.

Despite having enough food produced to feed the entire human population on Earth, the key contributing factor for world hunger is distribution (Uvin, 1994, 151). Several economical, technological, and societal factors prevent distribution of resources and food from reaching areas struggling with hunger and starvation. This research paper aims to look at these obstacles in

distribution of resources that keep world hunger a problem in a world where there is not a shortage of food and considers restructuring Computer Science curriculum to allow students to tackle real-world problems such as world hunger.

Technical Research Problem

Analysis of CS 3240: Advanced Software Development, Real World Applications, and CS Curriculum at University of Virginia.

In CS 3240: Advanced Software Development, the required project for the class is to design a web application which solves a real world issue within the University of Virginia community. The project assigned to my team was to create a housing application - a website students or citizens of Charlottesville can use to search through their housing options for the next year. The application allowed for landlords/ladies and companies to upload their housing opportunities onto the website and connected future tenants to these proprietors. In Charlottesville, there is a growing need for housing within the community. The growth of the university and the community has increased the overall costs of housing around the area and has pushed the poorer population of Charlottesville further and further out of the city. This website aims to provide users with information of where affordable housing can be found as costs of living increases all throughout the city.

The project was made with Django, HTML, CSS, and hosted on Heroku. Within the project groups, the workflow was distributed in a manner which closely resembled the workflow of real-world programming teams at larger companies. Roles were designated such as Scrum Master, Requirements Manager, Testing Manager, DevOps Manager, and UX Design. This

distribution of work allowed for each team member to contribute to the project but was most busy at different times of the project's life-cycle. For instance, a Requirements Manager would be responsible for surveying the client/customer as to the specific requirements the web application needed and to translate the wants and needs of the client into an actionable plan for the programmers.

In analyzing CS 3240: Advanced Software Development, the work done on the project and the distributed workflow of the class closely resembles the work and workflow done by programmers outside of the classroom and prepares students for what lies after graduation. In comparison to other Computer Science classes at the University of Virginia, there is a large divide between the work done in class and the work expected of programmers in their careers.

In considering only the workflow of Computer Science classes at the University of Virginia, there is none that accurately describes how programming teams work. In required classes such as CS 4102: Algorithms and CS 2150: Program and Data Representation, all work is to be done individually. The purpose of working individually is to test the knowledge of students and whether they possess the knowledge to solve programming problems. The issue is, at no time will there be a situation in which you are not allowed to discuss possible solutions with your peers. StackOverflow is a discussion forum website in which students and professional programmers are encouraged to post and discuss their issues. Computer Science at its core, is a collaborative space and collaboration should not be discouraged within the curriculum. Other courses, such as CS 4750: Database Systems, although work is required to be done in a group,

does not specify how work is distributed amongst group members. Use of collaborative tools such as Github, a version control system for programmers, is not required.

My proposal to the University of Virginia's Computer Science department is to create a new 1000 level course that introduces computer science students to basic software and systems commonly used in many classes and in the field as well as educates students on how to use their resources - both in the classroom through collaboration with their peers and with outside resources such as StackOverflow without violating the University Honor Code. The software and systems that should be taught in this course should include: Github, a collaborative version control and management system for programmers, introduction to Linux and VI/VIM text editors that are compatible with Linux as many programming languages are built specifically for Linux (C, C++), and network tools (SSH) to get students comfortable with the idea of working on remote machines on a secured work network. In my time at the University of Virginia, I was tasked to use these programs/systems on multiple occasions for different classes and depending on the class, it might be expected of students to have prior knowledge of these systems before enrolling in the class. It is for this reason that I believe it will serve the University of Virginia Computer Science department to create a 1000 level class to ensure all students are familiar with the programs commonly used in their field. As for educating students on how to use their resources, the University should choose to promote a collaborative environment which mimics the industry standard of having senior developers and peers who are able to help you. Of course, blatant cheating such as copying work should still be enforced, however, students should be encouraged to discuss and problem solve together, iteratively coming up with better solutions instead of being punished for working together (which is the case for CS 4102 and 2150 as

mentioned previously). Additionally, use of outside resources to understand a bug or why code may not run should be encouraged - with the limitations being that you cannot simply post your homework online for someone else to do nor should you be allowed to copy answers directly online.

STS Research Problem

Data Analytics and Its Role in Humanitarian Food Aid

How has new forms of data analytics changed humanitarian food aid? How can new forms of data analytics be developed to further assist countries suffering from food shortages?

Factors for Food Shortages

Food shortages and insecurity often occur in African countries. These counties have many similarities in terms of their economy, climate, and political issues that are preventing them from producing enough food to feed their country. The first issue in not being self-sustainable is climate and climate change. Across the Horn of Africa, many farming families experience periods of 'hunger seasons' which are time periods in between harvests where nothing can grow due to the climate (Ram, 2022). Africa, due to their proximity to the equator, faces a hot and dry climate, which does not promote crop growth. Additionally, climate change has had an increased effect in the past few years and fluctuations in the weather system has made havests less reliable.

In terms of political obstacles, these countries are generally underdeveloped and their lack of natural resources leads to lots of conflicts with neighboring countries. War and conflict in these lands has led to mass displacement, forced migration, and abandonment of potential farm land. Additionally, the lack of food and water access to its citizens can be attributed to the lack of political infrastructure to support agriculture. In comparison to the United States, where there is

clean water accessible nearly everywhere due to a system of pipes for distribution, there does not exist this type of infrastructure in African countries that are suffering from food insecurity.

If these countries cannot be self-sustainable, they must turn to trade and look to find/buy produce elsewhere. Unfortunately, due to their lack of natural resources, lack of political structure, and the devastation left behind from early colonialism, these countries face a nearly impossible challenge when attempting to be on the same economic footing as first world countries. Their challenges to be economically successful discourage trade between them and other countries, their lack of resources don't offer much variety and options that other countries may provide.

In looking at the solutions to alleviating food and hunger issues within these regions, there are not many positive incentives to helping these areas out. Economically, there is little/no value in sending food or resources where there is nothing to gain. However, given that access to food is a basic human right and is a necessity to survival, we should look to help these countries despite there being nothing to gain. Across the world, 30-40% of the food produced is lost or wasted, which is about 1.3 billion tons of food being wasted every year (Nooghabi, 2018, 567). Culturally, can we accept less produce in our grocery stores, restaurants, and in our homes that will eventually go to waste in order for it to go to a place that needs it more? Technologically, can we implement a method to distribute food to areas in need with low costs? Analytically, can we develop methods to track supply and demand, and make adjustments to these systems to assist with food aid?

Current Food Distribution Methods

There are currently two different methods of food distribution. First is through domestic distribution, also known as wet markets. Domestic distribution system is characterized by its remoteness to formal markets (Nooghabi, 2018, 566). Wet markets tend to be local farmers who sell their produce surplus at mostly low prices. However, their assets depend much on agricultural inputs, market information, or new technologies which may not always be available to the producers. Additionally, weather and climate conditions play a large role in how much surplus produce there is. Because of these reasons, domestic distribution is not a reliable method to distribute food across a developing country since they do not have a surplus to reliably create the market.

The second method of food distribution is market-oriented distribution. In the United States, this is the more common method of distribution with a formalized structure of suppliers, larger quantities and stricter quality control (Nooghabi, 2018, 566). Supermarkets are the most common example of market-oriented distribution. A limiting factor of market-oriented distribution however, is the cost. Due to a number of new factors such as the larger quantity, quality control, or shipping cost, market-oriented distribution tends to be significantly more costly to the consumer. This possesses a significant complication for developing countries as they do not have a booming economy.

Current Analytical Methods

The World Food Programme currently uses three main analytical innovations that have transformed their approach of humanitarian food aid: SCM-D, descriptive and predictive analytical model; Optimus, web-based application to design optimal food baskets and supply chain plans; and DOTS, a data integration platform used to automate and synchronize complex

data across multiple data systems, allowing SCM-D and Optimus to be deployed simultaneously and at a large scale (Peters, 2022).

First, the SCM-D was first deployed to adapt to the ever evolving field of humanitarian operations. In terms of hunger, each country likely has their own unique reason for their food shortage. As mentioned in the previous section discussing the factors for food shortages, these causes could be any mixture of climate, politics, economics, etc. When attempting to make an actional humanitarian plan for each suffering country, the root of the problem may be different and therefore, the solutions will also be different. SCM-D's analytic model made it possible to make predictive analytics - automatically flagging potential issues such as delayed shipments, gaps in distribution, and exporting stock. In addition to being predictive, SCM-D can also offer prescriptive analysis too, suggesting concrete actions such as: dispatching stock to certain locations and replenishing commodities for a cluster of countries (Peters, 2022). The main use within the World Food Programme is to project expected food availability over time and allows humanitarian aid to be properly allocated.

Optimus is a mathematical model which optimizes the distribution of goods and services to suffering countries. It simultaneously optimizes the sourcing/delivery plans and which commodities to distribute or, food baskets (Peters, 2022). This supply chain analytical model has already been implemented within the UPS Foundation, one of the largest parcel services in the United States. By utilizing Optimus, plans to distribute food made by the World Food Programme can be optimized to minimize costs, allowing for a greater volume of food distribution.

Finally, to cross analyze the data from both of the aforementioned models and other useful data, DOTS is utilized for data integration (Peters, 2022). For instance, data collected

from SCM-D may predict and prescribe a plan for a country that may soon be suffering from food shortages due to a period of poor climate. Optimus can then handle optimization of said plan in order to keep costs low for the World Food Programme, allowing more resources to be dedicated to other areas and allowing the World Food Programme to offer humanitarian aid to a larger percentage of suffering counties. This cross analysis of data from both SCM-D and Optimus is done within DOTS, who can also consider other analytical factors such as pricing information for each food basket and refer to nutritional databases to ensure a balanced diet.

Economic Crux, Analytics for Economic Distribution

As we analyze different food distribution methods, we quickly begin to see the crux of the issue for why neither distribution method works - it is not economically feasible for these countries. Wet markets don't work because there is not a surplus in supplies or money (if there was, there wouldn't be malnourishment) and market-oriented distribution doesn't work because the economy in these areas cannot support this method. The crux is apparent even as we narrow the scope. When we look only at the United States, a first world country with one of the largest economies in the world, it is almost inconceivable that 10.2% of the country also suffers from food insecurity (USDA ERS). When looking at the states most affected by food insecurity, it is those in the middle of the country, with less booming cities and economies to rely on. At the core of the issue, there is a divide between class and economy, with those who have less economic power also having less agency to control their food supply. So instead of thinking about distribution of food, we should instead think about distribution of wealth and technology so that poorer areas are able to take from the surplus of the rich areas.

With that in mind, while food distribution can offer short term aid for a country suffering from food shortages, it will likely make little to no impact on their long term food supply.

Bringing these areas out of poverty and assisting them with economic development is expected to solve world hunger on a larger, global scale than simply distributing food. For that reason, data analytics in humanitarian aid should be developed to make predictive and prescriptive models for why certain areas suffer from economic collapse. These factors can range from lack of technology, educational opportunities, work diversity, etc.

Evidence/Data Collection

To collect data on whether the analytic models used by the World Food Programme have worked or not, we can compare the state of world hunger before these analytic models were implemented and afterwards. Today's information about world hunger can be accessed with HungerMap, which is an interactive map of the world indicating the prevalence of insufficient food consumption for each country. Data of malnutrition, trade, currency, and COVID-19 can also be accessed from this website.

As for the economic question, depending on which factor is being focused on, different data may be collected. Again, similar to how a mixture of factors can be the reason for food shortage within a country, a mixture of factors can be the reason for a country's economic downfall. Maps for access to electricity or WiFi can be made by collecting data on each country and the availability of these resources. Alternatively, data of educational institutions and work information of citizens of countries can be analyzed to understand what type of opportunities are available for a given country. Using these data points, they can be input into an analytical model similar to SCM-D, Optimus, and DOTS to develop plans to bring countries out of poverty one by one.

Conclusion

From my STS Research Project, I hope to learn more about the crux that prevents food distribution to developing countries - which is one way to alleviate the issue of world hunger. Once these roadblocks are established, an actionable plan to create infrastructure within the communities of developing countries can be made to assist with their economy and food production. From a Computer Science prospective, infrastructure could mean implementing more affordable farm technology or creating a well organized database for food production and economy.

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