Affiliation: FAST-NUCES KARACHI Pakistan			
Department: Computer Science and Computer Information Systems Department, Faculty of Computing, and Information Technology		**Specialization:** Information Technology Artificial Intelligence **Domain**	
Proposal Title: IntelliCART (AI enabled Smart Cart)			
Required Budget 27,600 Dollars	**Proposed Duration (Max months)** 12 Months	**Desired Starting Date** 1st July 2023	
Name of the Investigator(s) (Full Name)	**Academic Title**	**Investigator's Affiliation (Dept. / College)**	**Nationality**
Principal Investigator **Dr. Muhammad Farrukh Shahid**	Assistant Professor	Computer Science Department FAST-NUCES Karachi Pakistan	Pakistani
Co-Investigator			
External Investigator			
Co-Investigator			
Signature of Principal Investigator			

ABSTRACT

In today's changing global market, the freshness and quality of produce such as fruits and vegetables have become increasingly crucial to purchasers. This task introduces a solution referred to as “IntelliCART” that aims to enhance customer self-belief and convenience while purchasing fruits and veggies from a cellular fruit cart. This gadget utilizes technologies including laptop imaginative and prescient, mobile applications, cloud generation, Global Positioning System (GPS), etc. to create a platform that offers actual-time monitoring of fruit and vegetable freshness price verification based totally on government regulations and location-based services for finding nearby-by fruit carts. The proposed solution now does not only benefit clients, but also presents benefits for fruit cart carriers. By using this gadget, carriers can construct a relationship with their customers by ensuring a pleasant warranty and doubtlessly expanding their consumer base. Furthermore, adhering to government pricing tips can help companies avoid headaches while retaining their reputation. In summary, the “IntelliCART” addresses issues associated with pleasant manipulation and truthful pricing for mobile smart carts. With its camera-based freshness assessment characteristic, price verification capabilities, and person pleasing mobile application, along with Global Positioning System (GPS) -based location offerings, it gives a solution that empowers purchasers to make choices while helping nearby farmers. This project brings together technology, agriculture and consumer awareness to create a more transparent and effective fresh produce market.

Keywords: Artificial Intelligence, IoT, Deep Learning, Computer Vision, Fruit Quality Monitoring, Cloud Technology, Mobile Application

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1. Introduction

The world's urge for food for clean and healthy meals has increased in recent years as people around the world have come to appreciate the importance of healthy consumption and living a wholesome lifestyle. fruits and vegetables containing nutrients and dietary fiber, an important supply of the human food plan [1]. However, making sure that fruits and veggies are fresh and actual has emerged as a greater project, especially when you're shopping from a fruit cart that doesn't have the infrastructure of a conventional retail outlet. Many clients are uncertain about the cost of the fruits and veggies they're about to shop for. To be able to address those issues and increase transparency in the marketplace for fresh produce, we're introducing a new idea: IntelliCART.

The proposed project makes use of cutting-edge technology, such as Computer vision, Cloud, and Mobile Application, as well as Global Positioning System (GPS), to offer purchasers real-time statistics on fruit and vegetable freshness, validate government-selected pricing, and find smart carts within the area. By combining these functions into a single platform, the goal is to facilitate, help clients make informed shopping choices, and make the fresh produce market more green and reliable.

This notion outlines the primary factors and capabilities of the system and discusses its benefits for clients and cart dealers. The integration of modern technologies with the agriculture and retail industries illustrates the cross-cutting nature of this project. The advanced agricultural fruit recognition system with an easy camera will play a remarkable function for farmers and popular people [2]. With the aid of improving consumer stories and empowering neighborhood providers, the "IntelliCART," is consistent with the wider objectives of promoting healthy consumption styles and supporting nearby economies.

Figure 01: Traditional Cart (Rehri-Wala)

Figure 02: Smart Cart (IntelliCART)

Contribution to Society

Tradional cart vendor sell fruits at their own will and the cutomer don't have idea to either trust with quality and prices with vendors. Our proposed solution have significant contribution to society. Many customers does not have knowledege related to quality and freshnness of fruits and veggetables, our project ensures that customer have access to high quality fresh fruits and vegetable by providing real time fresh assessments. using this functionality customer can make informed decisions. Second many vendors sell fruits and vegetables on their own choice of prices and not keeeping in regard the government mandated prices so our solution promotes fairness and transparency in pricing of fruits and vegetables by inducing government alloted prices. Proposed project enhaces transparency in market and customer can access information about freshness and pricing and promoting fair competition among vendors. This will increase trust between customer and vendors. For customer new in an area does not have idea where to find carts to buy fruits and vegetable so with the help of our proposed solution people can have location of those cart with quality assessment and fair pricing.

2. Literature Review

The concept of real-time monitoring and validation systems for fresh produce has gained substantial attention in recent years due to the growing concern among consumers about the quality and authenticity of the fruits and vegetables they purchase. This section reviews existing research that aligns with the proposed "IntelliCART" which aims to address these concerns through a comprehensive technological solution.

i. Freshness Assessment Using Computer Vision

Several studies have explored the application of computer vision techniques to assess the freshness of fruits and vegetables. Fruit Quality Recognition is a technique where a fruit can be scored or classified autonomously by an algorithm given input features such as photographs. For instance, in a recent work [1] , the authors designed an automatic model to recognize vegetables by image processing and computer vision approaches. These studies highlight the viability of utilizing visual cues for freshness assessment, which aligns with the proposed project's objective of real-time monitoring through camera-based analysis.

ii. Mobile Applications for Quality Assurance

The integration of mobile applications to enhance consumer experiences in purchasing fresh produce has been explored by researchers. PubMed and Web of Science were used to conduct this systematized review, and the inclusion criteria were: randomized controlled trials evaluating mobile phone applications focused on increasing fruit and/or vegetable intake as a primary or secondary outcome performed from 2008 to 2018. Eight studies were included in the final assessment. The interventions described in six of these studies were effective in

increasing fruit and/or vegetable intake [2]. The system aimed to provide consumers with real-time information about the products they placed in the cart. This resonates with the proposed project's focus on a user-friendly mobile application that delivers freshness indicators to customers, thus empowering them to make informed decisions.

iii. Government-Induced Price Validation

The concept of price validation based on government regulations is crucial to ensure fair pricing practices. While limited research directly pertains to this aspect, studies related to pricing transparency and regulatory compliance in various industries can offer insights. For instance, research in electronic marketplaces and e-commerce platforms emphasizes the significance of transparent pricing mechanisms to build consumer trust. Applying these principles to the proposed system would contribute to the project's aim of promoting fair pricing practices and ensuring regulatory compliance.

iv. Location-Based Services for Retail Enhancement

The utilization of GPS-based location services to enhance retail experiences has been well-documented. Existing literature in location-based services (LBS) highlights the benefits of providing customers with real-time information about nearby retail outlets and promotions. While most studies focus on permanent retail establishments, the proposed project seeks to extend these concepts to mobile fruit carts. By incorporating GPS functionalities, the project aims to facilitate consumer access to nearby fruit carts, aligning with LBS principles.

v. Cloud-Based Machine Learning and Deep Learning

The incorporation of cloud technology to process data and implement machine learning and deep learning algorithms is a pivotal aspect of the proposed system's architecture. Researchers have explored the benefits of cloud-based data processing. This aligns with the proposed system's aim to perform sophisticated analysis on cloud servers, delivering real-time freshness assessments to users.

Published	Classes	Method	Features	Classifiers	Reference
IRJET 2021	Apple, banana, Mango Disease	K-means clustering technique to cluster the images	color, morphology, Color Coherence Vector (CCV)	Support Vector Machine (SVM).	[3]
ICIRCA 2020	Banana disease	classifying the diseases in the banana plant at the	Feature extraction classification is mainly	Artificial Neural Network (ANN)	[4]

		earlier stage to prevent the nearby plants from the same diseases.	based on the pattern recognition		
Springer 2015	Apple diseases blotch, rot and scab	Threshold approach is used for segmentation. k- means clustering	Texture, shape and color features.	multi-class support vector machine	[5]
IRJET 2015	Apple scrub, apple bitter rot	image segmentation RGB to gray conversion median filter, edge detector, and morphology operation	Texture, shape and color features.	support vector machine	[6]
IJCSIT 2015	Pomegranate disease detection	Intent searching with k mean clustering	Color, Morphology and Texture	K-nearest neighbor algorithm	[7]

3. Description (Rationale) Of Proposed Work

The proposed mission, “IntelliCART” addresses vitally demanding situations within the contemporary clean produce marketplace, where customers' trust in the quality and pricing of end

results and greens from mobile carts is often compromised because of confined transparency and accessibility to data.

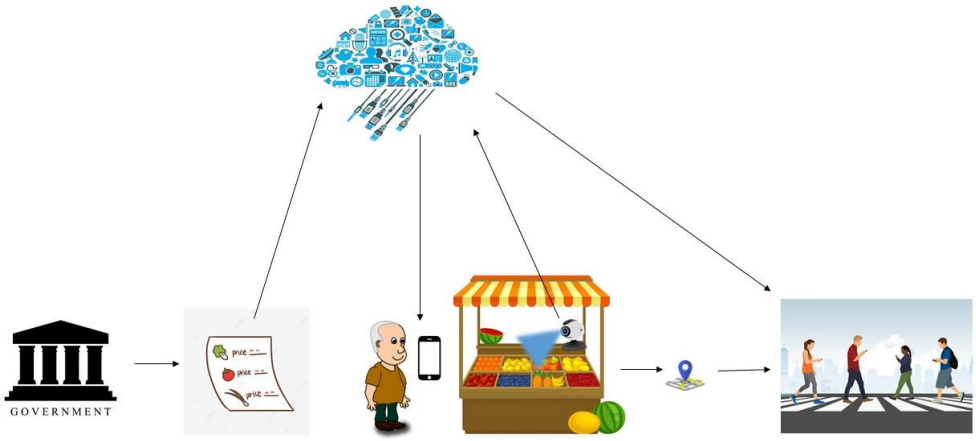


Figure 03: Scenario of Proposed Work

Figure 03 suggests the traditional technique of assessing freshness and quality, which might be subjective and regularly reliant on vendor understanding. Using computer vision in the proposed device provides a goal-driven, fact-driven way to assess the freshness of fruit and vegetables. By seeking out visual signs like coloration, texture, and spoilage signs, consumers can be certain of the authenticity of the goods they're about to buy. The purpose of government-imposed pricing is to save you from unjustified pricing practices and provide customers with a right of entry to nice, fresh products at less costly fees. This selection protects customers from overpricing while allowing sellers to stay aggressive within regulatory parameters. The appearance of cell applications has changed how purchasers interact with services and products. The proposed mobile7 application empowers clients by supplying them with real-time statistics on the freshness and costs of fruits and vegetables. Moreover, the combination of Global Positioning System (GPS) generation and publication guides customers to nearby fruit carts, enhancing convenience and inspiring help for neighborhood vendors. The above scenario displays the use of cloud-native deep learning (DL) and system gaining knowledge of Machine Learning algorithms to streamline photo information processing and guarantee real-time photograph freshness opinions. Cloud technology gives scalability and computing power, taking into consideration superior analyses that had been as soon as impracticable on a mobile phone. This makes the proposed gadget one of the most advanced of the era, providing purchasers with an easy experience and companies with a cutting-edge tool to capture and keep customers.

4. Research Objectives

The main objective of the proposed project is to develop a solution that addresses critical challenges in the fresh product market and improves the customer experience while supporting mobile cart vendors.

a. Develop a Real-Time Freshness Assessment Algorithm.
b. Integrate Government-Induced Pricing Validation.
c. Create a User-Friendly Mobile Application.
d. Utilize cloud technology to implement machine learning and deep learning algorithms for real-time data processing and analysis.
e. Implement GPS-Based Location Services.

The goal of the project is to develop a complete and innovative "IntelliCART" that is beneficial to both consumers and sellers in the market.

The tables 4.1 and 4.2 maps the objectives, approaches, phases, and the tasks carried out to implement the objectives.

Table 4.1 OBJECTIVES AND THEIR APPROACH MAPPING

Objective	Approach for achieving the objective
Develop a Robust Freshness Assessment Algorithm (1)	Use computer vision to find features like colors, textures, and any signs of damage.
Integrate Cloud technology, Deep Learning and ML Algorithms (2)	Implement cloud technology for efficient image processing; deploy deep learning and ML models for real-time freshness assessment.
Incorporate Government-Induced Price Validation (3)	Develop feature to match displayed prices against government-regulated price data, guaranteeing transparency
Implement GPS-Based Location Services (4)	Integrate GPS functionality into the app for identifying nearby fruit carts for each customer
Create an Mobile Application (5)	Design a user-friendly mobile app with real-time freshness information and all above mentioned features.

Evaluate System Performance and User Satisfaction (6)	Conduct testing to assess freshness, price validation , GPS accuracy, and take user feedback.

Table 4.2 OBJECTIVE PHASES AND TASKS MAPPING

Objectives	Phases	Tasks
1	Algorithm Development	1. Study computer vision techniques for color and texture analysis. 2. Algorithms for spoilage detection. 3. Implement a real-time image analysis algorithm.
2	Cloud Integration, Algorithm Development	1. Select cloud platform for image processing. 2. Develop and train deep learning models for freshness assessment.
3	Algorithm Development	1. Obtain official government price data sources. 2. Develop algorithm to compare displayed prices with government data.
4	Mobile App Development	1. Integrate GPS functionality into the mobile app. 2. Display nearby fruit cart locations.
5	Mobile App Development	1. Design user interface. 2. Implement real-time freshness assessment display. 3. Integrate validated pricing information. 4. Integrate GPS-based location services.
6	Evaluation	1. Conduct testing of freshness assessment algorithm. 2. Calculate accuracy metrics. 3. Collect user feedback on app usability and features.

5. Scope

The scope of the project is to develop a technological solution that solves the problems of quality assessment, price transparency, and availability of fresh fruit from smart carts nearby. The main focus of the project will be:

a. Create and implement a system architecture that integrates camera to measure quality, cloud, deep learning and ML algorithms, government price verification, and GPS location services.
b. Develop and implement computer vision algorithms to accurately measure the freshness of fruit and vegetables.
c. Create a user-friendly mobile application.
d. Efficiently process image data with the utilization of cloud technology and use deep learning (DL) and machine learning (ML) algorithms to evaluate freshness in real-time.
e. Create algorithms to verify the displayed prices of fruit and vegetables against the government mandated price data.
f. Include GPS functionality in the mobile application to enable users to access location-based services

6. Research Design

The research approach for resolving the mentioned issues will be implemented in seven phases. This approach will consist of data collection, the implementation of a deep learning model, and real world testing.

The project will consist of the following phase:

6.1.1 Phase 1: Comprehensive Literature Review

This initial phase will consist of a comprehensive literature review to identify the most recent developments in the fields of Computer Vision, Real-time Monitoring, Price Validation, and Mobile Application Development. Existing techniques for Freshness Assessment, Price Valuation, and GPS Based Services will be examined. This stage will form the basis for the adoption of the most up-to-date practices and techniques in the field.

6.1.2 Phase 2: Data Collection

The training and validation of this will involve the collection of a large dataset. This dataset will include images of fruits/vegetables, as well as their freshness levels and prices. Careful testing will be employed to ensure that the dataset is diverse

6.1.3 Phase 3: Data Pre-processing (Feature Extraction)

Once the dataset is collected, the features be extracted from the images. These features will include color gradients, textures and any visible spoilage indicators. These features will be used as input data for computer vision algorithms to make accurate freshness evaluations.

6.1.4 Phase 4: Algorithm Development and Cloud Integration

Deep Learning and Machine learning algorithms will be designed and connected with a cloud-based architecture to process image data and execute the algorithms. Algorithms will work together to provide consumers with real-time Freshness information and Pricing Valuation.

6.1.5 Phase 5: System Evaluation

The development of the system will be subject to testing. Precision, accuracy, recall, and the F1 score will all be evaluated to determine the efficiency of the freshness evaluation, price confirmation, and GPS location services. The system's capacity to deliver real-time data and usability will also be assessed.

6.1.6 Phase 6: Mobile Application Development

A mobile app will be created to make it easy for people to use the features of the system. It'll have a user-friendly interface that makes it easy to use for both the customers and sellers both.

6.1.7 Phase 7: Writing up and Documentation

This project will be documented in various formats, including journal articles, and technical reports. A user guide for both consumers and fruit cart vendors will be created to ensure effective system utilization. The mobile application and its functionalities will be documented through relevant platforms.

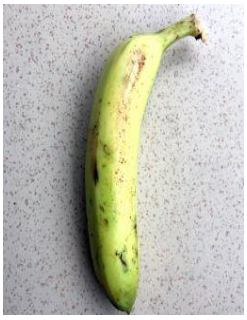
7. Research Methodology

7.1 Methodology

As discussed in the previous section, we will use deep learning and probability models for anomalies detection Now, we will be discussing experimental setup, deep learning model (training and testing phases), evaluation criteria.

i. Data Collection

Collect a dataset of images with different freshness levels and pricing information. Ensure that the dataset covers a wide range of products and includes instances of different freshness states and prices

Fruits	Dataset		
Apple			
Banana			
Oranges			

ii. Feature Extraction

Extract relevant features from the collected images, including color information, texture patterns, and visible signs of spoilage. These features will be an input data for the computer vision algorithms.

iii. Algorithm Development and Cloud Integration

1. **Deep Learning Model Development:** Develop deep learning models for Quality measurement, price validation, and GPS-based location services. Use convolutional neural networks (CNNs) for image analysis and classification tasks.
2. **Cloud Integration:** Design and implement a cloud-based architecture to process image data and run the deep learning algorithms. Ensuring efficient data transfer between the application and the cloud servers.

iv. Model Training and Testing

1. **Dataset Splitting:** Split the collected dataset into training validation, and testing sets. Use a large portion of the dataset for training and validation.
2. **Model Training:** Train the deep learning models using the training dataset. Fine-tune the models to optimize accuracy, precision, and recall for freshness assessment.
3. **Model Testing:** Evaluate the trained models using the testing dataset. Calculate performance metrics such as accuracy, precision, recall, and F1 score to assess the model's effectiveness in real-time scenes.

v. Mobile Application Development

1. **User Interface Design:** Design an intuitive UI for the mobile application. Ensure that users can easily access freshness assessment, price validation, and GPS-based location services.
2. **Functional Integration:** Integrate the developed deep learning models with the mobile application. Ensuring seamless interaction between the application's interface and the cloud-based algorithms.

vi. Evaluation

Calculate performance metrics, such as AUC curves, confusion matrices, and user satisfaction scores, to evaluate the system's effectiveness.

8. Management and Working Plans with Team Roles

8.1 Management Plan, Research Team, Roles, and Tasks

The work in this project will be conducted by a group of three members and one supervisor. We will meet once or twice a week to discuss the progress of the project and exchange information about the tasks given to each of them by the Group Leader. The expected duration of this project is 12 months. All investigators will be involved in all stages of the project and will work for one year. PI will spend the vacation periods reviewing and assessing the accomplished work up to that point. A progress report will be submitted every six calendar months. The final report will be submitted by the end of the 12th month, and it will present all details of the project.

Table 8.1 and 8.2 introduce and details the research team, their roles, tasks carried out by the team members and their timelines.

Table 8.1 ROLE AND INVOLVEMENT DURATION OF RESEARCH TEAM

Team Members	**Role**	**Duration** (months)
Ahad Shaikh (20K-0319) **Mohammad Basil Ali Khan (20K-0477)** **Syed Ali Jodat Naqvi (20K-0155)**	We intend to carry out this project as a group, in which each member is expected to be involved in literature review, model/tool building and testing, write-up	10 – 12

Dr. Muhammad Farrukh Shahid (Supervisor)	Dr. Muhammad Farrukh Shahid is a Principal Investigator who will be responsible for overall research project, both in the management of its activities and tasks as well as ensuring the consistency of how its various scientific parts (IoT and machine learning aspects) fit together. He will specifically be responsible for ensuring phases 2 and 3 of the project (data collection and feature extraction) are valid according to the scientific principles of the context so that our deep-learning models are properly contextualized.	10 – 12

Table 8.2 PROJECT TIMELINE MAPPED WITH THE TEAM ROLES AND PHASES

Timeline	Phases	Team Roles
Month 1	Literature Review	Ahad, Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 2	Data Collection	Ahad, Basil, Jodat, Dr. Farrukh
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 3	Feature Extraction	Ahad, Basil
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 4	Deep Learning Model	Ahad, Jodat, Basil
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 5	Model Testing and Optimization	Jodat, Ahad
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		

Month 6	Cloud Integration	Basil, Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 7 - 8	Mobile App Design and Development	Ahad, Basil, Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 9 - 10	System Integration	Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 11	Evaluation and Testing	Ahad
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 12	Documentation and Reporting	Basil, Jodat
Submitting Final Report		

8.2 Project Outcomes and deliverables

This research project develops a technological solution that solves the problems of quality assessment, price transparency, and availability of fresh fruit from mobile fruit cart.

The expected outcomes are as follows:

i. Enhanced consumer confidence.
ii. Fair pricing practices.
iii. Technological advancements
iv. User-Friendly mobile application.

The expected deliverables are as follows:

i. Deep learning and ML models.
ii. Dataset and experimental setup documentation
iii. Mobile application.
iv. Documentation and reports
v. Project summary and future recommendations.

9. Utilization

- It’s the consumers who benefit most from the system. With the help of the mobile app, they can get up-to-date freshness ratings, verified pricing data, and local fruit cart locations.
- By taking advantage of the system’s features, fruit cart vendors can increase and attract more customers.
- They can use the price validation feature to track and enforce government-sanctioned prices, making the market more transparent and fair.
- The use of cloud based deep learning (DL) and machine learning (ML) algorithms in this system demonstrates the real-world application of cutting-edge technologies in the agricultural and retail sectors.
- The methodology, results, and documentation of the project can be useful to researchers and academics who are interested in computer vision and real-time monitoring and technological solutions in agriculture.
- The success of this system could motivate entrepreneurs and companies to pursue similar ideas in other industries.
- The system encourages consumers to make informed purchasing decisions and encourages local fruit cart vendors to promote sustainable consumption practices and contribute to the development of local economies.

10. Curriculum Vitae (of each research team member)

The CVs of all team members are included in separate file.

11. Project Budget

SUMMARY

PROPOSED BUDGET (Dollars)

PROJECT TITLE		AI enabled IntelliCART						
DURATION		**(12) MONTHS**						
ITEM	**CATEGORY**	**NO.**	**COMPENSATION**	**FIRST HALF**		**SECOND HALF**		**TOTAL**
				MONTHS	**BUDGET**	**MONTHS**	**BUDGET**	
A-Research Team	**CONSULTANTS**							
	PRINCIPAL INVESTIGATOR							
	CO-INVESTIGATOR-2							
						TOTAL-A		

	PHD STUDENTS							
	MS STUDENTS							
	UNDERGRADUATE STUDENTS							
B-Assistants								
	TECHNICIANS							
	SECRETARIAL-CLERICAL							
	OTHER (programmers and developers)							

						TOTAL-B		
C-Computer Services & Consultants	**Cloud Services (AWS/AZURE)**		Deploying whole service on cloud (Storage Cost, Compute Cost, Data Transfer Cost, AI service Cost)	Internet connection and communicatin needs				$10,000
	Internet Usage							$500
	Consultant Services							
						TOTAL-C		$ 10,500

D-EQUIP. & MATERIAL	**Paperwork**			$100
	EQUIPMENTS MAJOR **(>100,000)** **Laptop/Mac, 2 Tensor GPU and CPU for Deep Learning (M2 Mac Studio 32GB RAM 512 GB SSD)**		To train deep learning algorithm	$15,000
	EQUIPMENTS MINOR **(>10,000)** **Camera, Arduino, Rasberry-Pi, GPS tracker, Wiring, Wi-Fi Dongle**		For real-time detection of Quality.	$1000
	Dataset Drives (Fuel cost)			$1000
	PATENT REGISTRATION			
	PUBLICATIONS			

	WORKSHOP	-		
	OTHER EXPENSES			
ITEM TOTAL				**$27,600**
GRAND TOTAL				

A. SALARIES (Research Team)	0%	
B. SALARIES (Assistants)	0%	
C. Computer Services & Consultants	**38%**	$ 10,500
D. EQUIP. & MATERIAL	**62 %**	$ 17,100
GRAND TOTAL	**100%**	$ 27,600

Conclusion

Our proposed solution is an important step towards addressing demand for fresh and healthy food with the authenticity of prices as well especially when purchasing from traditional carts. Our innovative solution involves modern cutting edge technologies that includes computer vision, cloud computing, mobile application development, and Global positioning system (GPS) to provide customer with freshness and price validation transparency. All above mentioned technologies merging in single platform will result in customer vendor strong relationship build on trust and fair market competition among vendors.

Summing up the “IntelliCART” provides an exciting and innovative solution with capability of revolutionizing fruit and vegetable market, enhancing trust and transparency and provides health food to customer.

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