Comprehensive Survey on the Techniques used in Weighing and Recording Systems

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Abstract **–**Today farmers are facing more problems about fruit's weight measuring and recording at the time of their final cost calculation while selling to the agents. Now a day, weighing issues are the most important in concern with the issues of farmers everywhere in the agriculture field, so weighing of everything from farm gains higher and higher importance in recent years. Here in this paper, trying to introduce the comprehensive literature study related to the various measuring systems that are necessary in the fields such as agriculture, industries and market. Weighing and measuring where possibilities of incursion are increasing day by day. In past days, the research is gone on various weighing and measuring systems, which provided the solution to manual methods. Due to the advancement in recent techniques, some weighing systems are based on microcontroller, ARM11, dynamic, fuzzy-logic, force-sensing, image-processing, filter, online, sensor network, and LVDT based etc. Every system has its own advantages and disadvantages. In most of systems, strain gauge technique is used for weighing so the system will become cost effective, more reliable and it will take less time to stores the many reading for continuous measuring process. The weight measuring systems today needs to make use of the latest technology. In some papers, the authors have presented weighing systems based on embedded and PLC and sometimes the load sensors is connected by online and sensor network. Hence, it could not easily hack the data of weighing records by hackers. A lot of modification takes places in various weighing and recording systems from the last few years, in next coming years many changes will takes place.

Key words **-** *RTOS, ARM Processor, and Load cell sensor.*

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I. INTRODUCTION

Importance of weighing systems is increasing in agriculture field day by days. Process of ensuring of weight and their recording function is very important for the prevention of manual error. Hence, focusing on weight measuring and recording is very important to avoid the manual error done by agents. Mostly it is made faulty so that less weight can be measured by agents. They are using manual method for noting down the reading on balance. A person who is noting down the measurements are also does manual error extensionally. Finally there is loss of farmers only so, there is a need discover the kind of balances which may not be faulty. So, many authors present different kinds of digital weighing systems, automatic PLC based weighing system, ARM11 based weighing system etc. which have been widely used in agricultural and industrial purposes for weighing of different type agricultural products using ordinary, mechanically, electronically balances which are set down manually. Nowadays, advanced automatic weighing systems are available with the use of ARM11, dynamic, fuzzy-logic, force-sensing, image-processing, filtering. Also online, sensor network, and LVDT based and many more that helps us for various measurements like measurements of their agricultural goods or industrial products.

II. LITERATURE SUREVY

Weight measuring and recording systems are classified based on technology used as microcontroller, ARM11, dynamic, fuzzy-logic, force-sensing, image-processing, filtering, and also online, sensor network, and LVDT based.

2.1. Dynamic weighing Technique

In the area of mass production, products are weighed using load cell based dynamic weighing systems. In a proposed system [1], a fuzzy logic estimator is proposed as weight filter for the dynamic weighing system. The structure of a fuzzy model is identified by the concept of fuzzy space clustering. The input-output space is clustered using a fuzzy C-means clustering scheme. Afterwards, the components of the result achieved show that unconventional method of filtering fuzzy logic estimator may provide the computationally effective method. Fig. 1 Show the effective schematic for proposed system. It is specifically designed for low weight measurement.

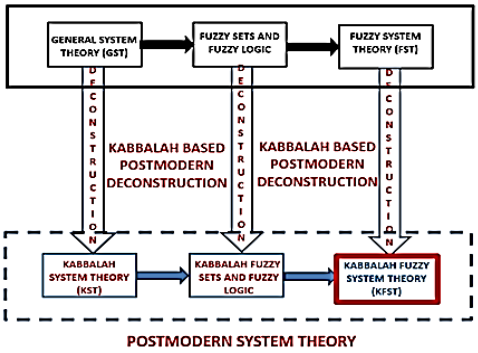

Fig 1: Symbolic Logic Reckoner for Dynamic System

A high weight system, in view of the current damage roads and bridges caused by overloaded vehicles, through analyzing the factors affecting the weight of vehicles in process of weighing, the vehicle dynamic weighing protective system [2] has been designed. It uses the linear regression method to establish a compensation rate of compensation factor model. Results show that this system that can be effectively used for dynamic load identification and road administration for vehicles with steel leaf spring suspension, but it is nice for adaptation convenience, man-machine conversation and is improvement in estimation of weight of moving vehicles. Similarly to increase the effectiveness and accuracy, a system [3] was developed based on Kalman filter which reduces the fluctuation and vibration of product weight and enhances the dynamic weighing system performance, which is observed in the real time, and extracts the correct weight of the product. This increases weighing accuracy while maintaining or increasing the production speed. The results achieved shows that the Kalman filter may provide effective alternative to the conventional methods especially when the system is nonlinear and low frequency noise is incorporated in the bandwidth of the useful signal. These systems are designed for dynamic but nearly stationary object measurements.

Conveyor belt-type check-weighers are increasingly popular components of modern production lines. Authors [4] are used to assess the weight of the produced items in high speed motion unlike to the systems discussed in [1, 2, 3], i.e., without stopping them on the weighing platform. The main challenge one faces when designing a dynamic weighing system is providing high measurement accuracy, especially at high conveyor belt speeds. The approach proposed in this system can be characterized as a filtering scheme based on the finite impulse response model of the weighing system response. It is shown that when such a model-based filtering is applied, the attained weighing accuracy is up to four times higher than that guaranteed by the currently available state-of-the-art solutions.

2.2. Processor/Image Processing based Technique

A new weighting sub-system [5] was designed for fruit sorting and grading machinery. Based on a fixed point DSP, it controls up to 10 lines at 20 fruit/second with an accuracy of ±1 gram. The system applies an adaptive filtering and a posterior de-convolution of the behavior of the load sensor using an ARMA model. A final estimation procedure to obtain weight in grams is also described. The best results have been obtained with an ALMS algorithm for the adaptive filter. Similar algorithmic based system [6] was invented based on Java and image processing for pig weighing measurement, in order to facilitate the measurement of pig body weight, coupled with development of information technology. It uses a non-contact measurement means. Detection of pigs with body size and weight estimate system requirements, to B/S architecture based system software design and development. Java programming language using image processing pig, Using MySQL database technology to achieve results in pigs weighing scale data storage and other related, in the My-Eclipse platform to achieve the detection of body size and weight of pig forecast system testing. Pig size is measured by digital image processing and analysis is done to achieve the automatic identification of pig feet and weight detection.

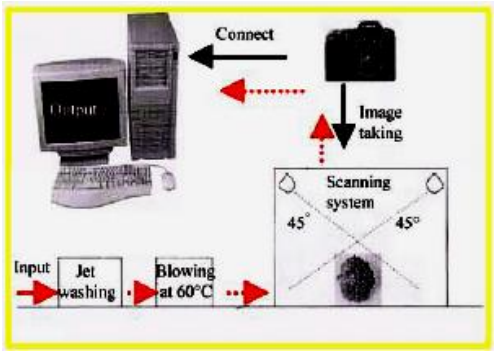

Fig 2: Fruit Grading System Setup [7]

As shown in Fig 2, a recently presented integrating system [7] discusses for grading by considering different attributes with the use of image processing. Fruits color and size detection are used to develop grading system based on image processing. Weight of fruit is used as a design metric to find out grading in food processing. For grading using color and size after capturing the fruit side view image, some fruit characters is extracted by using detecting algorithms. According to these characters, grading is realized. And for grading using weight as a parameter, the load cell arrangement can be used. Also by using GSM module the consumer or head office can get the idea about the grading process easily. Results show that this embedded system has the advantage of high accuracy of grading, high speed and low cost. This proposed system will have a good prospect of application in fruit quality detecting and grading areas.

2.3. Force Sensing Mechanism

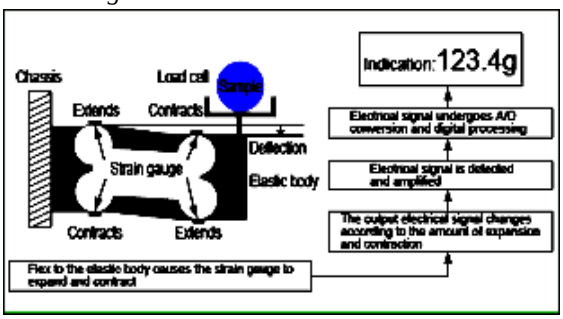

Fig 3: Load Cells in Force Sensing Structure [8]

Load cells are applied in several different fields as shown in Fig 3, usually for weighing measurements and also used to sense the compression forces during a robot's walk to provide data for the equilibrium-controlling system. The volume or level of a tank can be measured indirectly by means of a load cell that monitors the total weight. Lift units can also have a use of load's total weight to prevent overload. Because of such a variety of possible applications, load cells are very important. A work in [8] describes some of the theory and practice of load cells, including their basic elements and the electronics

necessary for measurement. As an application example, the development of a 3-ring spherical load cell [8] is presented which can be used to measure compression forces on fruit during storage and transportation is presented.

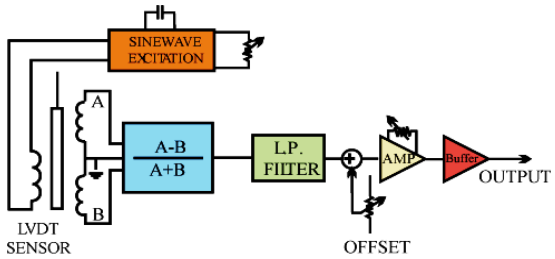

Fig 4: LVDT Based Digital Weighing System [9]

Load cell (Fig 4) includes strain gauge and strain gauge is also used in Linear Variable Differential Transformer (LVDT). LVDT has evolved into a highly accurate and reliable form of displacement transducer and has found widespread application in industry for the measurement of displacement, force or pressure. A system based on LVDT [9] discusses the design consideration of digital weighing system capable of weighing up to 1000 grams (1 kilogram). Atmel 89S52 microcontroller is used to acquire, to process and to display the weight on 16x2 LCD. The weighing system has been designed and calibrated using standard weights and is found to be simple and of low cost.

The pilot less fruit-transportation gyro car works in the economic forest, avoiding the obstacle on the rail is the prerequisite of its safe working. An ultrasonic obstacle avoidance system of fruit-transportation gyro car based on ARM embedded weighing system is introduced in an article [10]. The specific function of automatic control is implemented in this system. It could make the gyro car stop when detect an obstacle and when load is more than the specified load. It sends the information to the monitoring client through GPRS. Through the test, the ultrasonic obstacle avoidance system with load monitoring performs well and is reliable.

Most of the weighing machines available currently are the analogue types. Analogue weighing machines are often not very accurate and convenient to read. In a novel research [11], analogue weighing machine was obtained from the market and converted to a digital type. To do this, the extension of the spring in the analogue weighing machine was first converted into voltage using a simple voltage divider circuit. The output of the voltage divider (transducer) was then fed into a microcontroller that converts the analogue voltage into a corresponding digital value using the internal ADC embedded in a microcontroller. The microcontroller was programmed to display the mass and the corresponding weight of the measured weight simultaneously on a Liquid Crystal Display (LCD device). The readings of the digital weighing machine produced were used to compare that of a standard weighing type. The result showed that there was a mean deviation of 1.44Kg between the readings of the modified scale and the analogue type which served as the control. A simple product moment correlation coefficient was used to compare the two readings and the result obtained indicated that there was a near perfect correlation (0.9998) between the readings of the two scales.

2.4. Digital Filter based Technology

Mathematical models of the load cell and forcing functions are proposed in a research [12]. These models are used to examine the suitability of the proposed filter approach. Since this approach is based on the accurate model of the system in question, the exact model of the load cell based dynamic weighing system has been derived and presented. Therefore an adaptively approach has been considered and a solution is proposed. The results achieved shows that the filter may provide an effective alternative to the conventional method especially when the system is nonlinear and low frequency noise is incorporated in the bandwidth of the useful signal. Similarly in a system [13], mathematical equations are presented in which the multi-hopper weighing system is developed that weighs individually the materials in the two hoppers mounted on the one weighing section. In this system, individual calculation of the weight of material is done in each hopper by solving a simple simultaneous equation if the gravity points of material in each hopper do not change. The equation includes factors of the gravity points that are obtained by reading dimension of machine drawing. It had achieved the remarkable improvement of weighing accuracy by establishing of an equation with the factors reflecting the real gravity points.

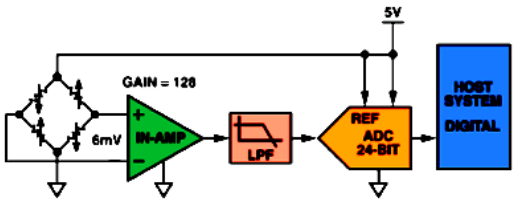

Fig 5: Filter for Dynamic Weighing System

The Electronics weighing bridges are comparatively light weight and easy to operate with direct display. Earlier electronic weighing machine were designed using DPM, Microprocessor and Personal computer. A specific work [14] using specific filter presented one such application in which a model with objective of measurement and display weight is developed. In this, load cell is used as transducer. Instrumentation amplifier is designed by using OP-07E operational amplifier, DSP filter and microcontroller AT89S52. ADC 0804 is used for data processing. A program is written in assembly language to display given weight on 16X2 matrix display. Finally the designed model has been tested and it is working satisfactory.

2.5. Sensor Network Technology

PLC based automatic weighing control system [15] was proposed for automation industry. Faulty jobs were rejected using PLC and accurate jobs were passed to further process on the conveyor belt. In industry, the production speed should be high because demand of the product is more. But when checking of the weight of the object is manually performed

then it will take more time for checking the weight and overall speed of the production will decrease.

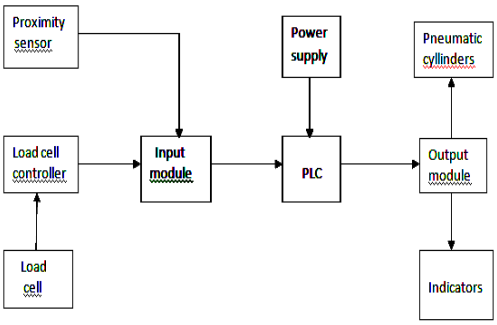

Fig 6: PLC based Automatic Weighing Control System [15]

In this work [15], a practical evaluation of the filtering method for weighing system is provided. The analyzed system form a part of the horticultural fruits sorting machine, which requires a fast and reliable weight measurements. Dynamic weighing of moving objects requires fast and adaptive signal processing techniques in order to guaranty a timely response. Thus, applied signal filtration technique ensured that the constant component remains free of noise, transient responses of load cell as well as mechanical vibrations. In similar system [16], fast non-stationary filtering method is applied, providing optimal tradeoff between response times and settling time of steady state value. The implementation method uses the distributed approach, where an intelligent sensor captures raw signal and applies adaptive filter. Subsequently, obtained value is transmitted to central unit that applies weight compensation function to improve the measurement accuracy. All the presented results used the real signal acquired in industrial conditions from the tests of sorting machine prototype. The analyzed approach obtains promising results for all sorting modes. Moreover, classical filtering approach is used for comparison purposes and performance evaluation.

Typical load cell characteristics are listed and some factors concerning loading are given in a novel system [17]. An all-electronic system for digitizing the output of load cells directly is described, and details are given of some basic systems used to obtain control and information facilities from the digital weight-sensor network signals, with some fundamentals of the binary arithmetic used.

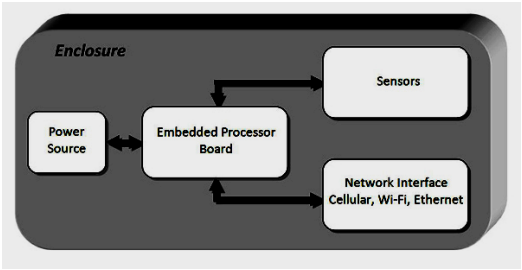

Fig 7: Sensor Network Interfacing To Weighing System [17]

A system for measuring the weight of apples and oranges [18] moving along a conveyor belt is described. The system relies on the effect of the moisture in the fruit on the resonant frequency and the Q-factor of a resonant waveguide cavity. It used a processor based system. Similarly, microcontroller based system based system is proposed in [19]. Electronic weighing machines are smart with the advantages like accuracy, reliability, and wide range. The Electronics weighing bridges are comparatively light weight and easy to operate with direct display. Earlier electronic weighing machine were designed using DPM, Microprocessor and Personal computer. Personal computer based system cost is very high. To remove this drawback microcontroller based weigh machine [19] has been designed. In same way as [18], a new MMS-based system [20] was proposed and developed with signal processing for fruit grading for consumers. In it, the prototype network architecture and integration of wireless messaging system with signal processing between mobile consumers are designed for development purposes.

In view of the weakness of present weighing system for mining shovel, a recent work [21] presented a designing method for mining shovel weighing system based on wireless sensors network technique. The configuration of hardware of sensor node, and software design are introduced in detail. Experiments show that the system has high measuring precision, good stabilization and is easy to install.

Wireless platform based weighing scales [22] was developed for the implementation as part of a smart beehive in a work. A single point impact load cell was selected as the most appropriate load sensor and was integrated into the design of the scales. The final weighing system was interfaced via a high precision analogue to digital converter to an off-the-shelf processing platform which was enabled with a low power Zigbee radio to allow for data transfer to the base station. An initial simulation of the scale's ability was carried out using standard weights to simulate the brood chamber of a beehive and varying weight to mimic the production and consumption of honey. The results showed that the initial platform scale has a linear output characteristic. The analogue to digital converter was evaluated and the system was found to be able to detect changes in weight in the order of tens of grams. A power analysis of the system was also undertaken to confirm that the solution which was suitable for remote, battery powered, deployments.

2.6 High Accuracy/Precision Technology

Jafaripanah et. al. [23] investigated the application of analog adaptive techniques in load cell response correction. The load cell is a sensor with an oscillatory output in which the measuring contributes to response parameters. Thus, a compensation filter needs to track variation in measuring whereas a simple, fixed filter is only valid at one load value. To facilitate this investigation, computer models for the load cell and the adaptive compensation filter have been developed and implemented in P-Spice. Simulation results are presented the effectiveness and accuracy of the proposed compensation technique. Similar highly accurate system in an article called “Fast and high-accuracy design and implementation for home electronic weighing scale applications," [24] is proposed. Based on Consumer Electronics, the system is developed in

which area of mass production is covered. The products are weighed using a load cell based weighing system. A load cell is an uncontrollable weighing device. Improvement in filtering increases the speed of weighing and enhances the measurement accuracy. A new algorithm and architecture is proposed as weight filter for the weighing system. We verify and implement the novel algorithm in the measuring products successfully.

The error in the process of automatically mixing of glue and dosing is removed precisely by using a system called Micro-D [25] based on load cells in parallel. The system has the characteristic of batching weight loading for each chemical components flow. Experimental results show that the design of glue mixing and dosing precise system Micro-D can accord with the requirement of precise measurement for glue mixed.

Checking of the weight of product in manufacturing process is performed in a novel system [26]. A software user interface along with the signal conditioning and data acquisition hardware has been fabricated. As the system is easily customizable, its seamless integration is always possible in a highly automated industry. Thus, there is a great potential for this system to be used in numerous industries, where load measurement formation is a part of the manufacturing process.

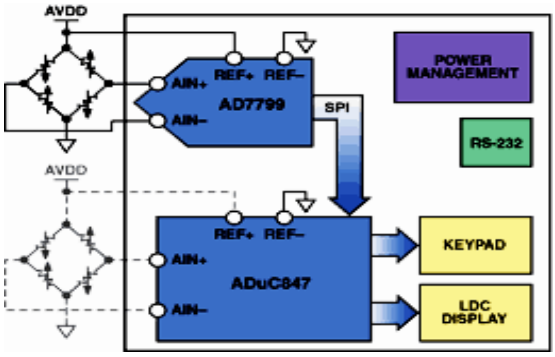

Fig 7: Weight Measurement System [27] Using Pic Microcontroller

A new algorithm and architecture [27] is proposed as weight filter for the weighing system. Authors verified and implemented the novel algorithm in the measuring products successfully. They discussed the development of a load cell based the static weighing system. In particular, the focus is on using digital filtering techniques to remove the measurable noises from the extremely low frequency noise of the static weighing system. In this design, the high resolution ADC is used with precision sensor signal conditioning and data acquisition. Modern ADCs offer high grade code resolutions to 24 bits, and greater than 19-bits of noise-free code resolution. The inclusion of on-chip PGAs in this ADC is coupled with the high resolution virtually that eliminates the need for signal conditioning circuitry. The precision sensor can interface directly with the ADC in many cases and further can be accessed by microcontroller to enhance measuring capabilities with embedded platforms. The designed system has good accuracy with high precision.

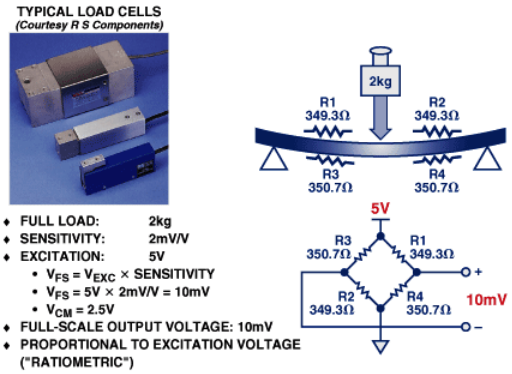

Fig 8: Typical Load Cell [28] with Sensitivity & Excitation

To develop an automatic digital electronic weighing system, a system [28] is developed that totally operated with the help of solar energy. In our country, the continuous supply of the electricity is a major problem. This system describes the design and implementation of energy efficient, low cost, small size, high efficiency, high accuracy with wide range of weighing digital electronic weighing system. This system totally works on solar energy due to that a lot of electric energy can be saved. This system also works with the help of emergency LED light. The system uses LDR to check the condition of Ac supply. The designed system measures weights ranging from 0-40 kg. Similarly high precision research work [29] shows the design and implementation of high resolution advanced digital weighing scale based on 24-bit sigma-delta ADC along with fully featured touch controlled 5.6 inch TFT display screen, 2.4GHz wireless remote display link, RS232 link for computer attachment, RC5 remote control operation and thermal printer connectivity for billing. Basically we have carried out work that how efficiently we can use the 24 bit sigma- delta ADC and several software as well as hardware level techniques to achieve great resolution. Now a day's requirement of measuring up to 1mg, 5mg accuracy on resistive strain gauge (which is low cost) which requires highly professional work to get the stable reading at above mentioned accuracy. Providing high precision is the prime goal and with that designing user friendly software functionalities like, types of weight unit conversions, power saving operation, real time data with computers, printer for billing, 6-digit memory store and recall facilities, common calibration system, tare system etc. The main agenda we have tried to implement behind this design are low cost and complete solution of customer side [30].

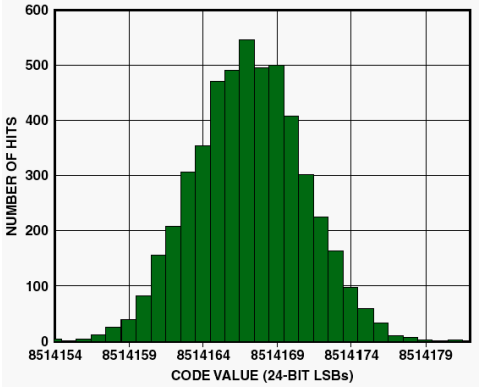

Fig 9: Graph of Improving the ADC Result [29]

A novel system for banana hand bunches measurement [31] is recently proposed in which a problem of manual interference is totally removed by developing a fully automatic system. No human interference is possible in this system and measurement is displayed on the screen. The specific rate calculation called difference based rating is implemented in this work. It is developed with embedded system included a ARM 11 processor (Raspberry pi) to facilitate internet access. Similarly, various processors can be used in weighing systems instead of old processor like 8051 and 89c51 these are ARM 7 [32, 33], ARM11 [31, 34, 35] and Arduino [36] used in various embedded systems for seed up and accuracy purpose.

III.SUMMARY

Recently proposed weighing and recording systems based on various technologies like dynamic weighing, DSP/Image processor, Force sensing Technique, Digital filter, Sensor network, and High accuracy/precision technology are studied and their problems are enlisted in TABLE 1. As per the requirements, authors developed the systems. Day by day weighing technologies are developed specifically for agricultural measurements.

TABLE I: Summery

SR. NO.	WEIGHING TECHNIQUES		
	Specific Technique	References	Problems
1	Dynamic Weighing		Need to improve reliability and robustness
2	DSP/Image Processing		Upfront installation expensive.
3	Force-sensing		Mechanical equilibrium-controlling system Not constant.
4	Digital Filter		Small-error transient responses of load cell as well as mechanical vibrations.
5	Sensor Network		Sensor-node software, connectivity problems due to abnormal weather.
6	High-accuracy/precision		More-memory required to store the data

IV. CONCLUSION

In today's technologically advanced world, automatic weighing systems are gaining rapid popularity so the advancement in latest technology is continuously and rapidly made on different latest automatic measuring and recording systems. The need for automatic weighing systems for fruits measuring using new technologies is increases day by day as accuracy and precision become a very important or serious issue for everybody. Due to the recent trends, various methods of weighing, agriculture sector, fruit market etc are developed. There is no need to worry about this weighing any longer, as automatic weighing systems are here to deal with it. This paper tries to focus all recent techniques in a comprehensive way.

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