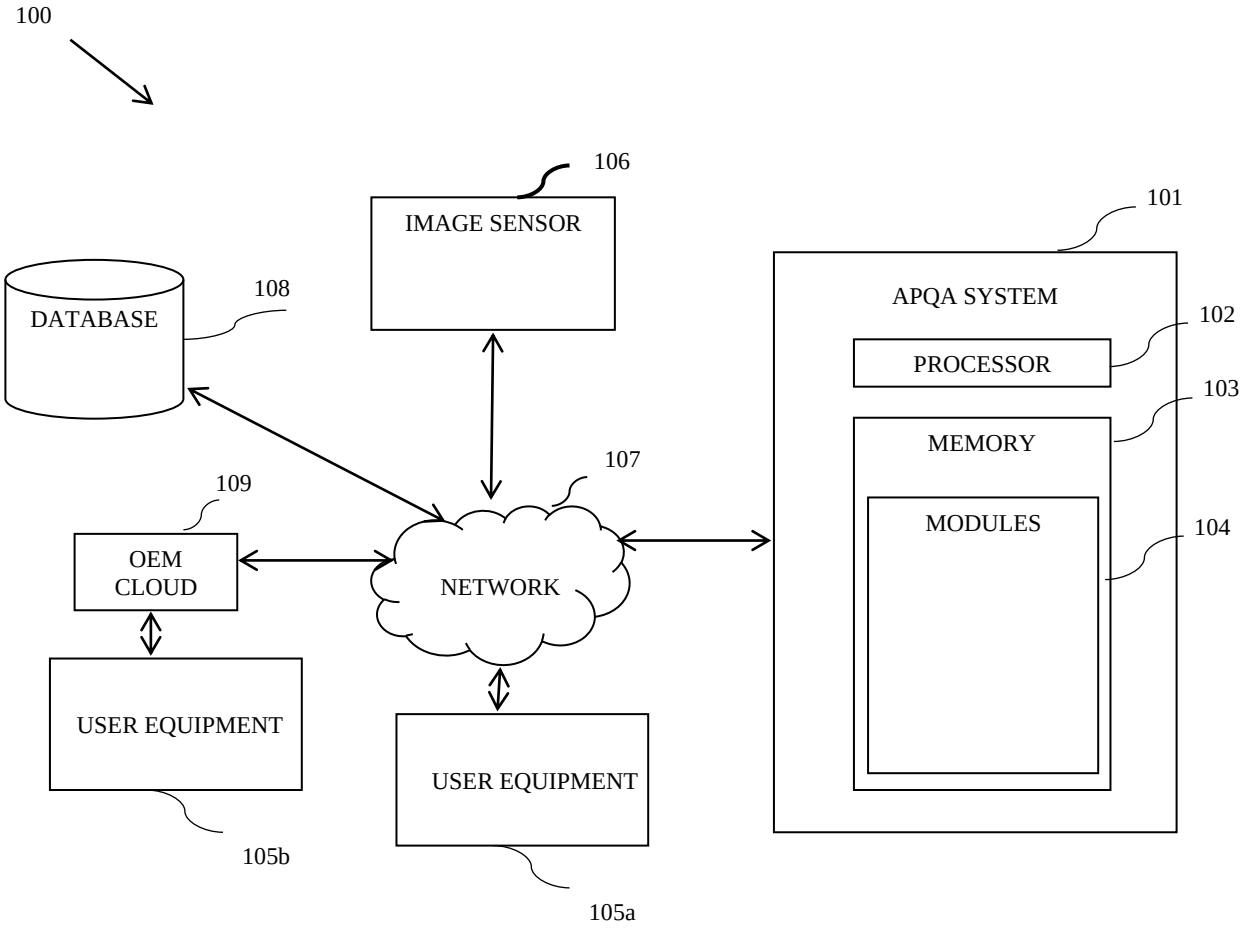

Fig. 1

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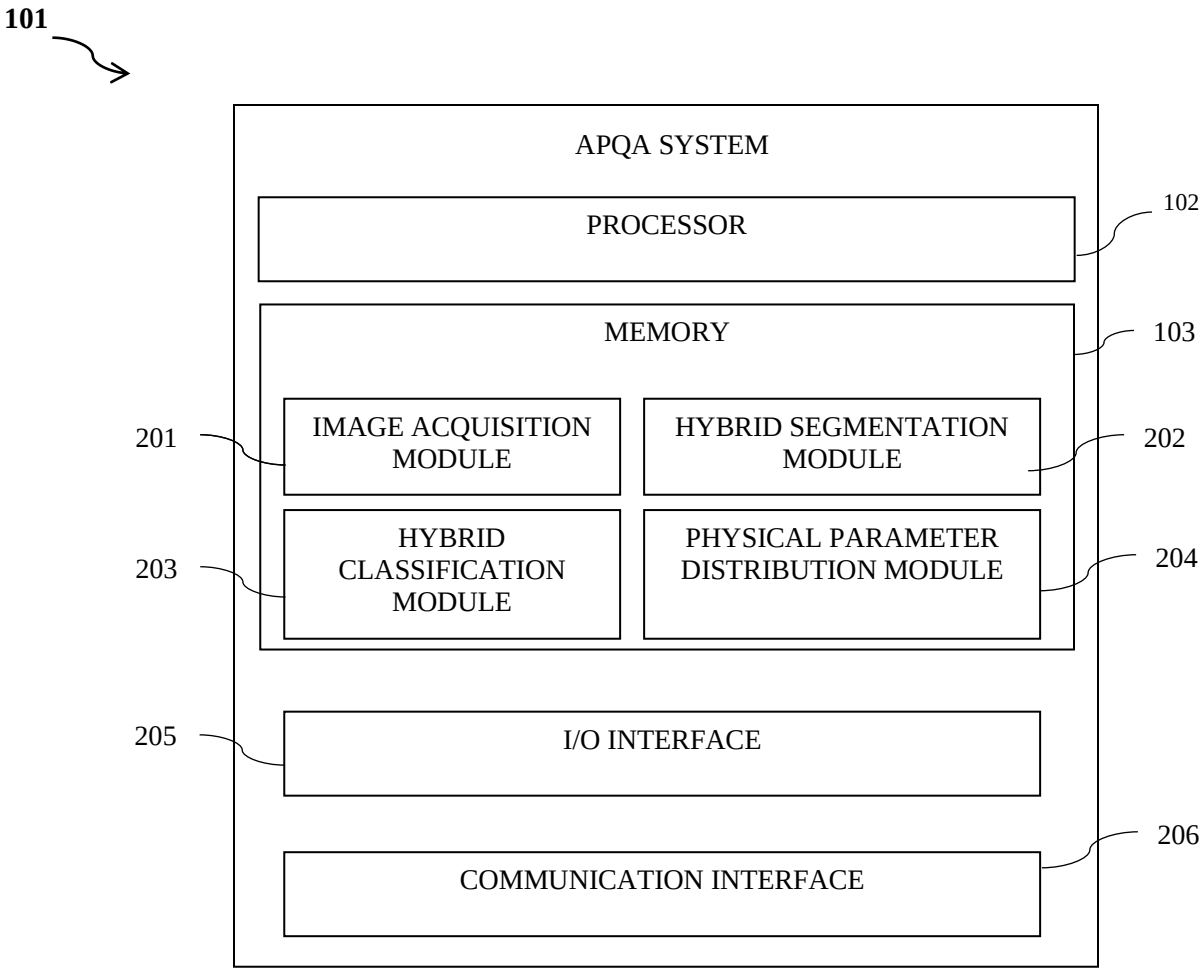

Fig. 2

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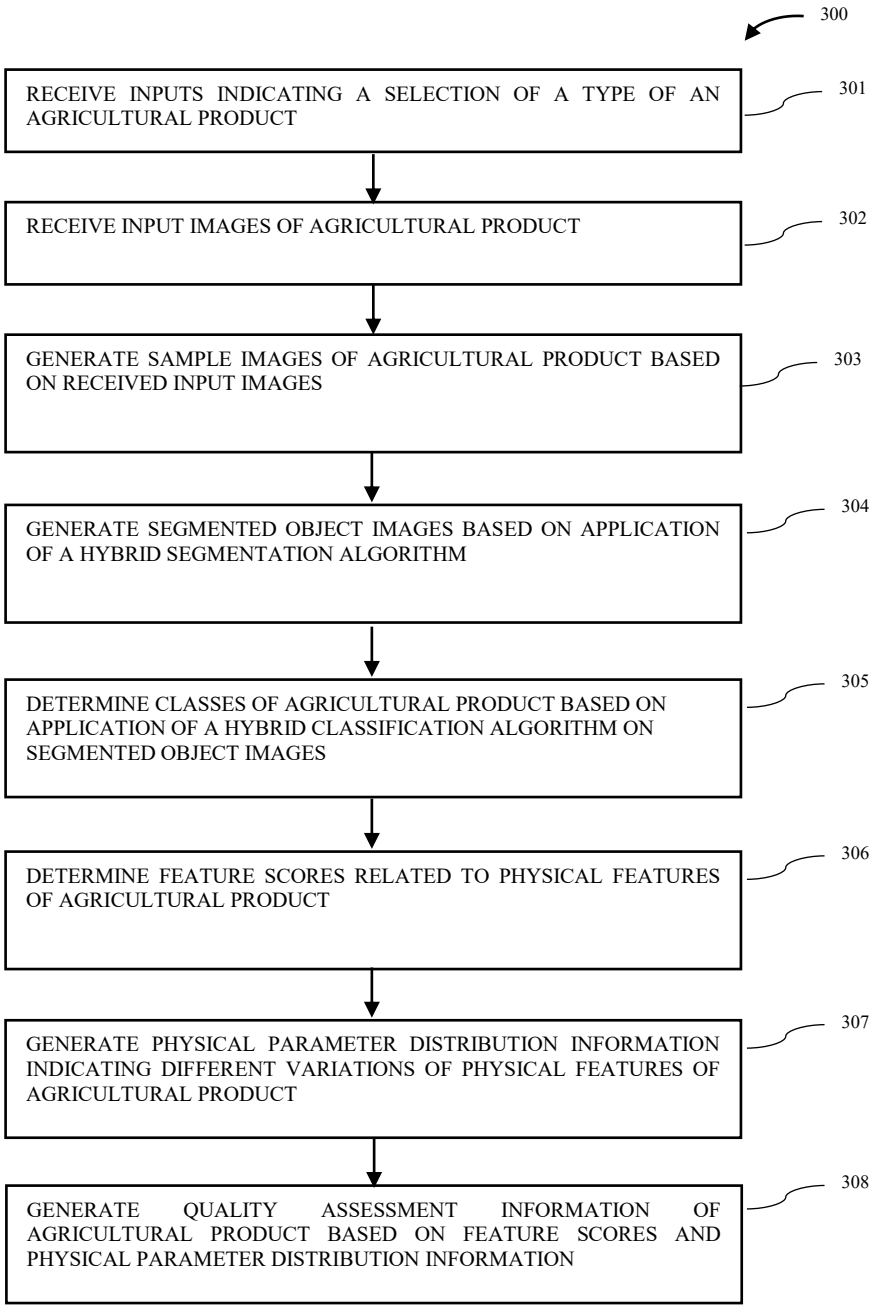

Fig. 3

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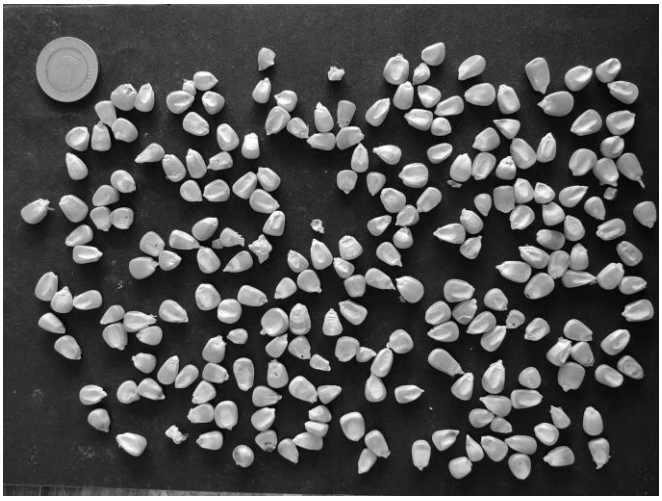

Fig. 4A

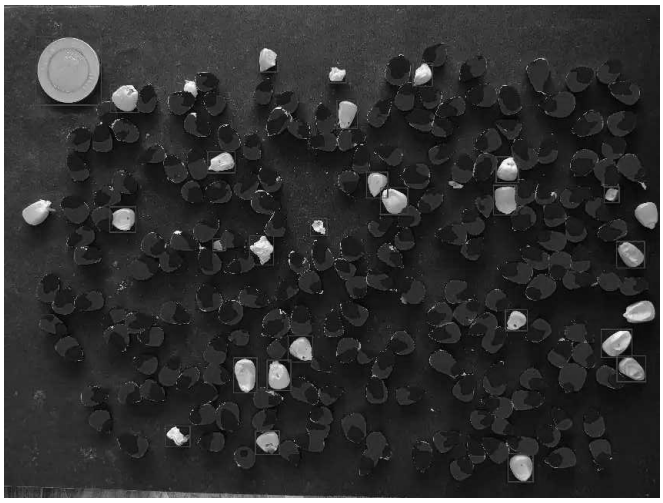

Fig. 4B

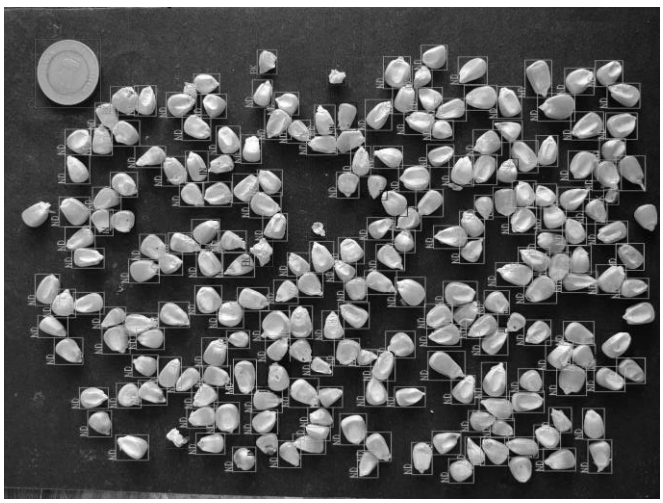

Fig. 4C

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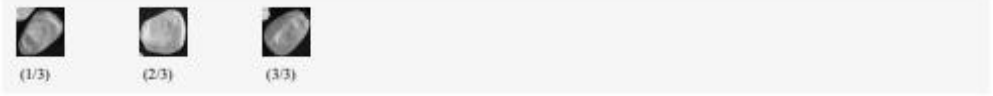
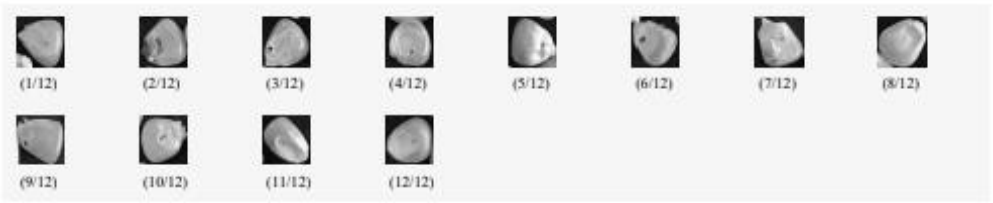
Kernel Type No Defect Kernel 194/219



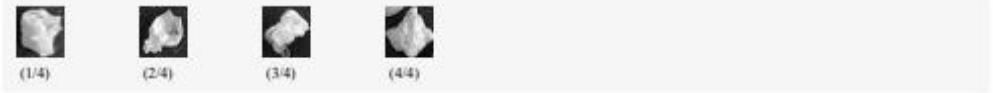
Kernel Type Mold Kernel 3/219



Kernel Type Insect Kernel 12/219



Kernel Type Foreign Kernel 4/219



Kernel Type Broken Kernel 6/219



Fig. 5

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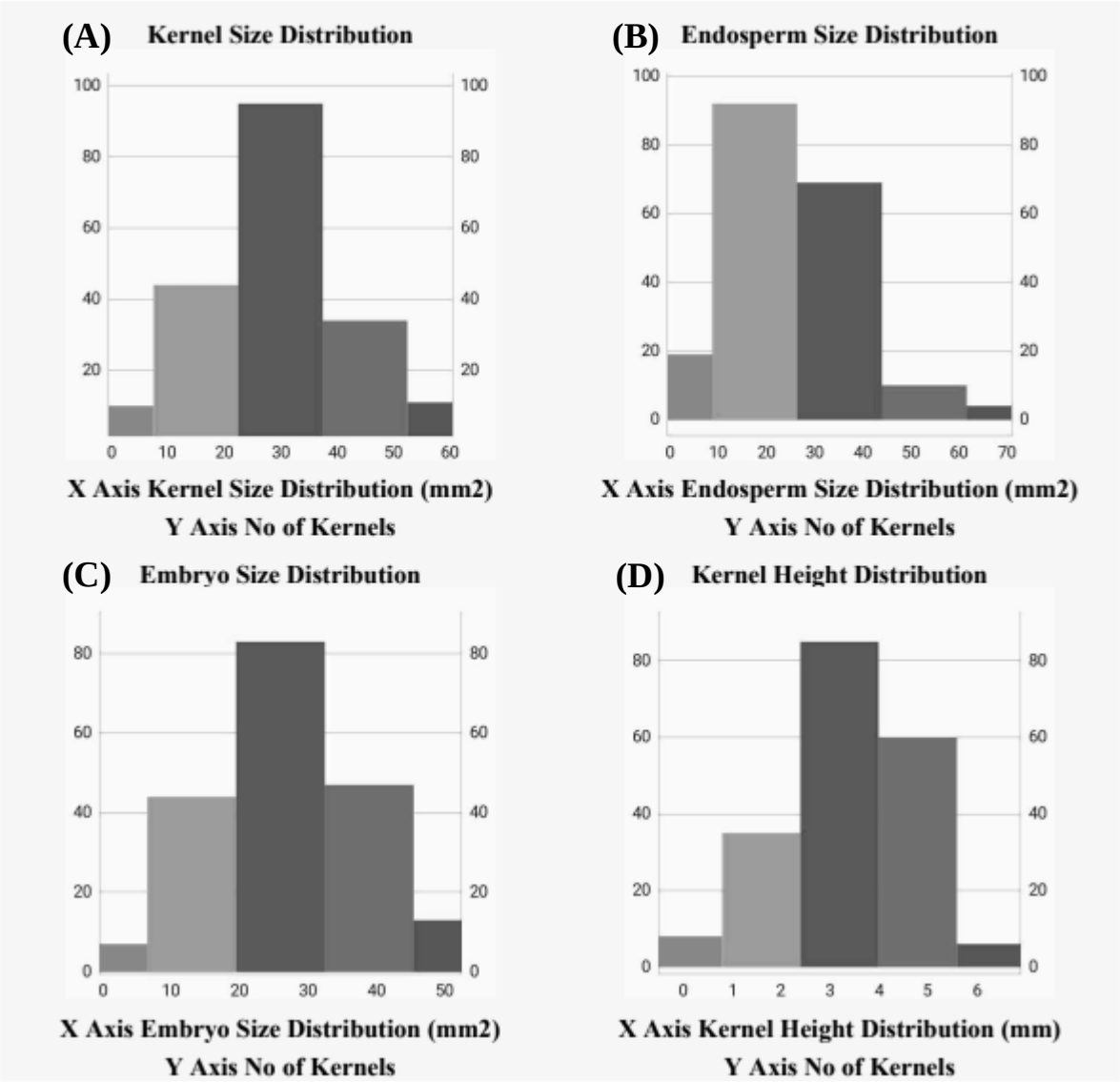

Fig. 6

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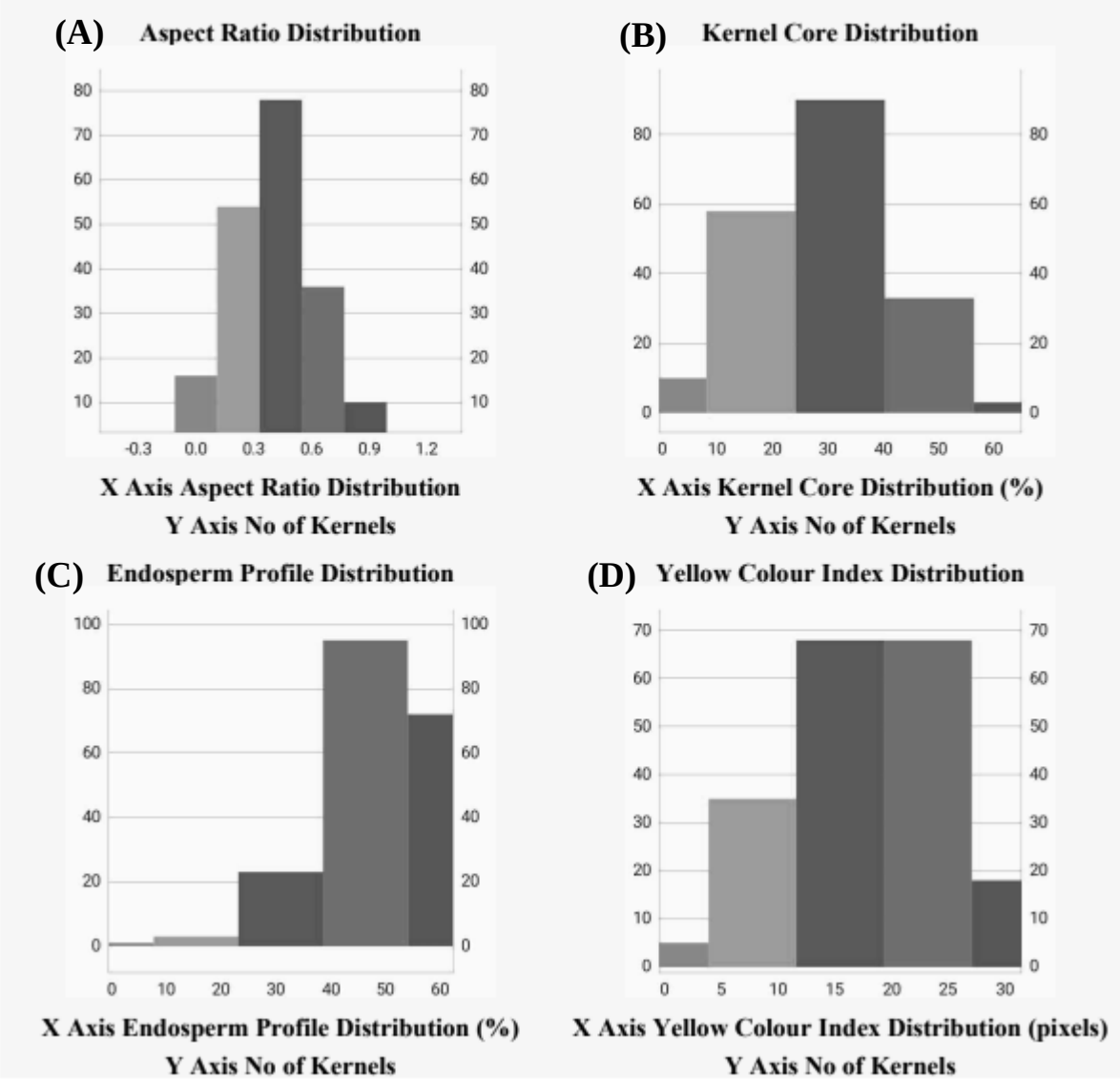

Fig. 7

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FORM 2

THE PATENT ACT 1970

[39 OF 1970]

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The Patents Rules, 2003

COMPLETE SPECIFICATION

[See section 10; rule 13]

"METHOD AND SYSTEM FOR QUALITY ASSESSMENT OF AGRICULTURAL PRODUCT"

APPLICANT

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The following specification particularly describes the invention and the manner in which it is to be performed.

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to the field of AgriTech, and more specifically to a method and system for assessing the quality of agricultural product.

BACKGROUND OF THE INVENTION

[0002] Quality being the first and most important parameter to decide the cost of any commodity traded, transactions of trillions of dollars agri-commodity relies merely on speculations leading to cost-quality paralysis. Without quality assessment at the time of purchase, buyers suffer in procuring quality stock. In general, grain type and quality are identified manually by visual inspection by human inspectors. Intrusion of human subjectivity in grading paves way for unfair deal. Further, lack of transparent payment system leads to exploitation of the sellers. The absence of digitalization of grading mechanism at sellers'-end lead to costly rejections at buyers end if discrepancies in expected and actual quality. Hence, the quality assessment process require automation utilizing computer vision techniques that can be helpful to analyze different food grain images and accordingly determine pricing.

[0003] A number of different types of methods, apparatus and system for quality checking of grains and kernels are available in the prior art. For example, the following patents are provided for their supportive teachings and are all incorporated by reference: One prior art discloses about a crop classification system and method, and the system comprises a shape analysis subsystem which is used for analyzing the shape of a crop; a quality analysis subsystem used for analyzing the quality of crops, a three-dimensional image reconstruction subsystem used for carrying out three-dimensional modeling on the acquired images of the front and back surfaces of the crops and converting two-dimensional plane image information into three-dimensional images for electronic archiving, a surface defect detecting and positioning subsystem used for detecting specific positions of imperfect grain defects of crops, and a crop image automatic classification subsystem used for classifying imperfect grains and perfect grains of crops.

[0004] Yet another prior art reference discloses a corn kernel test analysis method based on image processing, relates to the technical field of computer image processing, and aims at better applying the image processing technology to corn kernel test analysis and overcoming the disadvantages of being low in speed, error-prone and high in the requirements for image taking

equipment and image quality in image segmentation. The key points of the scheme are that step one, an image is preprocessed by using graying, filtering and noise reduction, binarization and open operation so that an ideal binary image is obtained; step two, the central position of the kernel is searched by using a distance transformation method; step three, classification and segmentation are performed on a kernel connecting domain by using the characteristics of the central position of the kernel and the area characteristics; and step four, the external contour parameters of the kernel are searched.

[0005] Yet another non-patent literature prior art reference discloses a comprehensive survey on recent computer-vision based food grain classification techniques. It includes state-of-the-art approaches intended for different grain varieties. The approaches proposed in the literature are analyzed according to the processing stages considered in the classification pipeline, making it easier to identify common techniques and comparisons. Additionally, the type of images considered by each approach (i.e., images from the: visible, infrared, multispectral, hyperspectral bands) together with the strategy used to generate ground truth data (i.e., real and synthetic images) are discussed.

[0006] Yet another non-patent literature prior art reference discloses a digital image processing techniques for quality grading of the rice grains. The techniques discussed in the prior art is for achieving uniform standard quality and precision, machine-vision based techniques. The technique considers physical parameters, such as Grain size and shape, chalkiness, whiteness, milling degree, bulk density and moisture content, for grading the rice grains using canny edge detection.

[0007] Yet another non-patent literature prior art reference discloses a software package, named GridFree, for image analysis for interactive grain counting and measuring. GridFree uses an unsupervised machine learning approach, K-Means, to segment kernels from the background by using principal component analysis on both raw image channels and their color indices.

[0008] Yet another non-patent literature prior art reference discloses method for detecting and counting all corn kernels in a single corn ear image taken in uncontrolled lighting conditions. The sliding window approach uses a convolutional neural network (CNN) for kernel detection. Then, a non-maximum suppression (NMS) is applied to remove overlapping detections. Finally, windows that are classified as kernel are passed to another CNN regression model for finding the

(x, y) coordinates of the center of kernel image patches. Experiments provided in the prior art indicates that the proposed method can successfully detect the corn kernels with a low detection error and is also able to detect kernels on a batch of corn ears positioned at different angles.

[0009] However, above mentioned references and many other similar references has one or more of the following shortcomings: (a) accuracy; (b) speed; (c) involves complex hardware and algorithm; (d) expensive; and (e) only limited to a specific type of grain or kernel.

[0010] Therefore, for the above reasons there is need in art of an automated method for cost effective comprehensive quality assessment of various types of agricultural product with high accuracy and high speed of determination. In the present invention, we have developed a lite and highly accurate deep learning and image processing algorithm for image analysis to be utilized for quality assessment of agricultural product.

SUMMARY

[0011] One or more shortcomings of the prior art are overcome, and additional advantages are provided through the present invention. Additional features and advantages are realized through the techniques of the present invention. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the claimed invention

[0012] The main aspect of the present invention relates to a method for quality assessment of agricultural product using an agriculture products quality assessment (APQA) system, the method comprises of receiving one or more inputs indicating a selection of a type of an agricultural product and receiving one or more input images captured by one or more image sensors after placing a sample of said agricultural product on plain color surface with a size-reference coin. The method processes the received input images to generate one or more sample images using one or more compression techniques, segment the sample images by an application of a hybrid segmentation algorithm to create one or more segmented object images using hybrid segmentation module. The application of hybrid segmentation algorithm is based on said selection of said type of agricultural product based on agricultural product type selection. The method further classifies the segmented object images in to one or more classes and/or sub-classes of said agricultural product by a hybrid classification module involving machine learning model, classical image processing, artificial intelligence model, and combination thereof. The method further determines one or more feature scores related to one or more physical features of agricultural product and

preparing physical parameter distribution, by physical parameter distribution module, to show the variations among all agricultural product in the sample image for every physical feature. The method generates quality assessment information of agricultural product based on feature scores and physical parameter distribution and controlling an output device to render the generated quality assessment information of agricultural product.

[0013] Further, the present invention relates to an agriculture products quality assessment (APQA) system for quality assessment of agricultural product. The system comprises one or more processors, one or more image sensors coupled with the one or more processor and a memory storage communicatively coupled with the one or more processors. The memory stores processor-executable instructions, which on execution, cause the one or more processors to receive one or more inputs indicating a selection of a type of an agricultural product and one or more input images captured by one or more image sensors after placing a sample of said agricultural product on plain color surface with a size-reference coin. The one or more processors process the received input images to generate one or more sample images using one or more compression techniques, segment the sample images by an application of a hybrid segmentation algorithm to create one or more segmented object images using hybrid segmentation module. The application of hybrid segmentation algorithm is based on said selection of said type of agricultural product based on agricultural product type selection. The one or more processors further classify the segmented object images in to one or more classes and/or sub-classes of said agricultural product by a hybrid classification module involving machine learning model, classical image processing, artificial intelligence model, and combination thereof. The one or more processors further determine one or more feature scores related to one or more physical features of agricultural product and preparing physical parameter distribution, by physical parameter distribution module, to show the variations among all agricultural product in the sample image for every physical feature. The one or more processors generate quality assessment information of agricultural product based on feature scores and physical parameter distribution and further control an output device to render the generated quality assessment information of agricultural product.

[0014] According to some example embodiments, the method further comprises the step of calculating pricing information of agricultural product, based on generated quality assessment information and market pricing information of agricultural product.

[0015] According to some example embodiments, the method of generating of one or more segmented object images, the method comprises the step of rejecting one or more pixels of one or more samples images related to undesirable small particles such as dust, generating plurality of segmentation masks based on application of instance segmentation on one or more sample images; and generating one or more segmented object images based on generated plurality of segmentation masks.

[0016] According to some example embodiments, the method of generating of one or more segmented object images, the method further comprises generating one or more bounding box in one or more sample images based on application of a trained object detection model on one or more sample images; generating plurality of segmentation masks based on generated bounding boxes; and generating one or more segmented object images based on generated plurality of segmentation masks.

[0017] According to some example embodiments, the method of determining one or more classes of agricultural product based on application of a hybrid classification algorithm on one or more segmented object images of agricultural product, the hybrid classification algorithm further comprises at least a machine learning model, classical image processing, or an artificial intelligence model and a combination thereof.

[0018] According to some example embodiments, the method of determining one or more feature scores related to one or more physical features of agricultural product wherein the feature scores include but not limited to shape, texture, lustre, an average kernel/grain size, an aspect ratio index, a profile index, a size uniformity, moisture, an average grain height, a core index, a color index or other related visual features.

[0019] According to some example embodiments, the method generates configurable test report and statistical data based on determined feature scores related to one or more physical feature of agricultural product and generated physical parameter distribution information.

[0020] Another aspect of the present invention is to provide a method for quality assessment of agricultural product using an agriculture products quality assessment (APQA) system, wherein the method performs quality assessment online and offline.

[0021] Another aspect of the present invention is to provide an agriculture products quality assessment (APQA) system, wherein agriculture products quality assessment (APQA) system is portable and configurable to adjust quality parameters and/or information related to one or more physical feature of said agricultural product as per the requirement of user or procuring authority.

[0022] Another aspect of the present invention is to provide an agriculture products quality assessment (APQA) system, wherein agriculture products quality assessment (APQA) system is configured for sending test report and statistical data to server, laboratory, or concern authority.

[0023] These together with other objects of the invention, along with the various features of novelty, which characterize the invention, are pointed out with particularity in the disclosure. For a better understanding of the invention, its operating advantages and the specific objects attained by its uses, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated preferred embodiments of the invention.

BRIEF DESCRIPTION OF DRAWINGS

[0024] The above and still further example embodiments of the present invention will become apparent upon consideration of the following detailed description of embodiments thereof, especially when taken in conjunction with the accompanying drawings, and wherein:

[0025] FIG. 1 illustrates a block diagram of a network environment of a system for quality assessment of agricultural product, in accordance with some embodiments of the present invention.

[0026] FIG. 2 illustrates a detailed block diagram of APQA system of FIG. 1 in accordance with an embodiment of the present invention.

[0027] FIG. 3 illustrates a flow diagram of a method of assessment of quality of agricultural product in accordance with some embodiments of the present invention.

[0028] Fig. 4A, 4B & 4C illustrates images at the various stages of the method according to an example embodiment of the present invention.

[0029] Fig. 5 illustrates various classified images of agricultural product based on application of a hybrid classification algorithm on the segmented object images in accordance with an example embodiment of the present invention.

[0030] Fig. 6 & Fig. 7 illustrates graphs representing different physical parameter distributions of the agricultural product in accordance with an example embodiment of the present invention.

[0031] The figures illustrate embodiments of the invention for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the invention described herein.

DETAILED DESCRIPTION

[0032] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention can be practiced without these specific details. In other instances, systems, apparatuses, and methods are shown in block diagram form only in order to avoid obscuring the present invention.

[0033] Reference in this specification to “one embodiment” or “an embodiment” or “example embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. The appearance of the phrase “in one embodiment” in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Further, the terms “a” and “an” herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not for other embodiments.

[0034] Some embodiments of the present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments of the invention are shown. Indeed, various embodiments of the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather,

these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like reference numerals refer to like elements throughout.

[0035] The terms “comprises”, “comprising”, “includes”, or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a setup, device, or method that comprises a list of components or steps does not include only those components or steps but may include other components or steps not expressly listed or inherent to such setup or device or method. In other words, one or more elements in a system or apparatus proceeded by “comprises… a” does not, without more constraints, preclude the existence of other elements or additional elements in the system or method.

[0036] Furthermore, one or more computer-readable storage media may be utilized in implementing embodiments consistent with the present invention. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps or stages consistent with the embodiments described herein. The term “computer-readable medium” should be understood to include tangible items and exclude carrier waves and transient signals, i.e., are non-transitory. Examples include random access memory (RAM), read-only memory (ROM), volatile memory, non-volatile memory, hard drives, CD ROMs, DVDs, flash drives, disks, and any other known physical storage media.

[0037] The embodiments are described herein for illustrative purposes and are subject to many variations. It is understood that various omissions and substitutions of equivalents are contemplated as circumstances may suggest or render expedient but are intended to cover the application or implementation without departing from the spirit or the scope of the present invention. Further, it is to be understood that the phraseology and terminology employed herein are for the purpose of the description and should not be regarded as limiting. Any heading utilized within this description is for convenience only and has no legal or limiting effect.

DEFINITIONS

[0038] The term “agricultural product” may be used to refer to any agricultural commodity or grain that includes, but not limited to, legumes, beans, grains, cereals, kernels, oilseed, dry-fruits, pulses, nuts, seeds and any related agriculture crops.

[0039] The term “machine learning model” may be used to refer to a computational or statistical or mathematical model that is trained on classical ML modelling techniques with or without classical image processing. The “machine learning model” is trained over a set of data and using an algorithm that it may use to learn from the dataset.

[0040] The term “artificial intelligence model” may be used to refer to a model built using simple or complex Neural Networks using deep learning techniques and computer vision algorithms. Artificial intelligence model learns from the data and applies that learning to achieve specific pre-defined objectives.

END OF DEFINITIONS

[0041] Grain quality depends on individual kernel features. The structural study of grains targets the exterior part of grains. The structural study covers parameters like size means length and width measurement, color and glossiness checking, aspect ratio. Structural study is done either by human or image-based analysis. Detailed measurement of grain shape such as length and width commonly depend on laborious techniques such as manual measurement of single grains. Manual analysis of grains is done either by eyes or using measuring instruments. Manual measurement doesn’t guarantee quality. The results of the analysis may differ if the samples to be analyzed are more numerous. For measuring individual nucleus parameters, image analysis and machine learning techniques have proven to be a very efficient solution. Compared to analyzing the samples by visual observation, the instrument measurement has more accurate results. Further, there are various types of agricultural product that are required to analyze for finding the commercial values of the agricultural product. The agricultural product is of the various colors, sizes and shapes. Analyzing qualities of the various agricultural product on a real time basis is a challenging task, the present invention provides a novel and unique method for quality assessment of the agricultural product.

[0042] Embodiments of the present invention may provide a method, a system, and a computer program product for quality assessment of agricultural product. The method, the system, and the computer program product assessing the quality of agricultural product in such an improved manner are described with reference to Fig.1 to Fig. 7 as detailed below.

[0043] Fig. 1 illustrates a schematic diagram of a network environment 100 of a system 101 for quality assessment of agricultural product, in accordance with an example embodiment. The system 101 may be communicatively coupled to an image sensor 106, a user equipment 105a, an OEM (Original Equipment Manufacturer) cloud 109 connected to a user equipment 105b, and a server 108, via a network 107. The components described in the network environment 100 may be further broken down into more than one component such as one or more sensors or application in user equipment and/or combined together in any suitable arrangement. Further, it is possible that one or more components may be rearranged, changed, added, and/or removed without deviating from the scope of the present invention.

[0044] One or more image sensor 106 may be configured to communicate with the system 101 over the network 107 and provide input images for quality assessment. In an example, the image sensor 106 may be integrated into a single platform such as the user equipment 105a and/or 105b and/or the system 101. The image sensor 106 may be a camera, industrial camera or any image acquisition device capable of capturing image of the agricultural product. In one embodiment, the image sensor 106 may be a camera-based scanner and CCD camera scanner. The image sensor 106 may capture two images from two sides. The image sensor 106 may capture one or more images from multiple angles to capture a 300-degree view of agricultural product. In another embodiment, the image sensor 106 may also store the captured image in the database 108 for future references.

[0045] The agriculture products quality assessment (APQA) system 101 includes a processor 102 and a memory 103 and various modules 104. In one embodiment, the processor 102 includes a single processor and resides at the agriculture products quality assessment system (APQA) 101. In another embodiment, the processor 102 may include multiple sub-processors and may reside at the agriculture products quality assessment system (APQA) 101 as well as the user equipment 105a and 105b. Further, the memory 103 includes one or more instructions that may be executed by the processor 102 to capture image of an agricultural product placed on a background with a reference object such as coin, process the captured image to generate sample images, perform object detection, hybrid segmentation, hybrid classification, compute feature score related to one or more physical features of agricultural product, generate physical parameter distribution information indicating different variations of one or more physical features for quality assessment information of agricultural product. In one embodiment, the memory 103 includes the modules

104, and other data (not shown in figure). The other data may include various data generated during processing the captured images stored in a database 108. In one embodiment, the database 108 is stored internal to the agriculture products quality assessment system (APQA) 101. In another embodiment, the database 108 may be stored external to the agriculture products quality assessment system (APQA) 101 and may be accessed via the network 107. Furthermore, the memory 103 of the agriculture products quality assessment system (APQA) 101 is coupled to the processor 102.

[0046] In some example embodiments, the user equipment 105a and the user equipment 105b (hereinafter, also referred to as "the user equipment 105a, 105b") may be any user accessible device such as a mobile phone, a smartphone, and a portable computer. The user equipment 105a, 105b may comprise a processor, a memory, and a communication interface. The processor, the memory and the communication interface may be communicatively coupled to each other. In such example embodiments, the user equipment 105a, 105b may comprise processing means such as a central processing unit (CPU), storage means such as on-board read only memory (ROM) and random access memory (RAM), sensors such as image sensor or camera, microphone, position sensors such as a GPS sensor, a proximity sensor, motion sensors such as accelerometer, a display enabled user interface such as a touch screen display, and other components as may be required for specific functionalities of the user equipment 105a, 105b. Additional, different, or fewer components may be provided. For example, the user equipment 105a, 105b may be configured to execute and run mobile applications such as a messaging application, a browser application, an image processing application, and the like. In one embodiment, at least one user equipment such as the user equipment 105b may be directly coupled to the system 101 via the network 107. The user equipment 105a or 105b may be configured to capture image data associated with an agricultural product. The one or more user equipment 105a, 105b may be communicatively coupled to the system 101, the server 108, and the OEM cloud 109 over the network 107.

[0047] The network 107 may be wired, wireless, or any combination of wired and wireless communication networks, such as cellular, Wi-Fi, internet, local area networks, or the like. In one embodiment, the network 107 may include one or more networks such as a data network, a wireless network, a telephony network, or any combination thereof. It is contemplated that the data network may be any local area network (LAN), metropolitan area network (MAN), wide area network (WAN), a public data network (e.g., the Internet), short range wireless network, or any

other suitable packet-switched network, such as a commercially owned, proprietary packet-switched network, e.g., a proprietary cable or fiber-optic network, and the like, or any combination thereof. In addition, the wireless network may be, for example, a cellular network and may employ various technologies including enhanced data rates for global evolution (EDGE), general packet radio service (GPRS), global system for mobile communications (GSM), Internet protocol multimedia subsystem (IMS), universal mobile telecommunications system (UMTS), etc., as well as any other suitable wireless medium, e.g., worldwide interoperability for microwave access (WiMAX), Long Term Evolution (LTE) networks (for e.g. LTE-Advanced Pro), 5G New Radio networks, ITU-IMT 2020 networks, code division multiple access (CDMA), wideband code division multiple access (WCDMA), wireless fidelity (Wi-Fi), wireless LAN (WLAN), Bluetooth, Internet Protocol (IP) data casting, satellite, mobile ad-hoc network (MANET), and the like, or any combination thereof.

[0048] In an example embodiment, the system 101 may be embodied in one or more of several ways as per the required implementation. For example, the system 101 may be a standalone unit configured to generate quality information of agricultural product. Alternatively, the system 101 may be coupled with an external device such as camera or any other agriculture field equipment. In one embodiment, the system 101 may be embodied as a cloud-based service, a cloud based application, a remote server based service, a remote server based application, a virtual computing system, a remote server platform or a cloud based platform. As such, the system 101 may be configured to operate outside the user equipment 105a and/or 105b. However, in some example embodiments, the system 101 may be embodied within one or both of the user equipment 105a and the user equipment 105b, for example as a part of a mobile app in a mobile device and the like. In some other embodiments, the system 101 may be an OEM (Original Equipment Manufacturer) cloud, such as the OEM cloud 109. Thus, the server 108 may enable provision of cloud-based services for the system 101, such as, storing the quality assessment observations in the OEM cloud 109 in batches or in real-time. In each of such embodiments, the system 101 may be communicatively coupled to the components shown in Fig. 1 to carry out the desired operations and wherever required modifications may be possible within the scope of the present invention.

[0049] Fig. 2 illustrates a block diagram of the APQA system 101 for quality assessment of agricultural product, in accordance with an example embodiment. The system 101 may include a

processing means such as at least one processor 102 (hereinafter, also referred to as “processor 102”), storage means such as at least one memory 103 (hereinafter, also referred to as “memory 103”), and a communication means such as at least one communication interface 206 (hereinafter, also referred to as “communication interface 206”). The processor 102 may retrieve computer program code instructions that may be stored in the memory 103 for execution of the computer program code instructions. The system 101 may be accessed using the I/O interface 205. The I/O interface 205 may provide an interface for accessing various features and data stored in the system 101. The I/O interface may comprise a display interface based on a touch input and configured for displaying various information related to quality assessment information.

[0050] The processor 102 may be embodied in a number of different ways. For example, the processor 102 may be embodied as one or more of various hardware processing means such as a coprocessor, a microprocessor, a controller, a digital signal processor (DSP), a processing element with or without an accompanying DSP, or various other processing circuitry including integrated circuits such as, for example, an ASIC (application specific integrated circuit), an FPGA (field programmable gate array), a microcontroller unit (MCU), a hardware accelerator, a special-purpose computer chip, or the like. As such, in some embodiments, the processor 102 may include one or more processing cores configured to perform independently. A multi-core processor may enable multiprocessing within a single physical package. Additionally, or alternatively, the processor 102 may include one or more processors configured in tandem via the bus to enable independent execution of instructions, pipelining and/or multithreading.

[0051] Additionally, or alternatively, the processor 102 may include one or more processors capable of processing large volumes of workloads and operations to provide support for big data analysis. In an example embodiment, the processor 102 may be in communication with the memory 103 via a bus for passing information among components coupled to the system 101.

[0052] The memory 103 may be non-transitory and may include, for example, one or more volatile and/or non-volatile memories. In other words, for example, the memory 103 may be an electronic storage device (for example, a computer readable storage medium) comprising gates configured to store data (for example, bits) that may be retrievable by a machine (for example, a computing device like the processor 102). The memory 103 may be configured to store information, data, content, applications, instructions, or the like, for enabling the apparatus to

carry out various functions in accordance with an example embodiment of the present invention. For example, the memory 103 may be configured to buffer input data for processing by the processor 102.

[0053] Referring to Fig. 2, the modules 104 of memory 103 includes an image acquisition module 201, a hybrid segmentation module 202, a hybrid classification module 203, a physical parameter distribution module 204. The modules 104 are instructions stored in the memory 103 and may process a captured input images to facilitate quality assessment of agricultural product. The image acquisition module 201 is configured to receive input images of an agricultural product. The input image may comprise image of agricultural product with a background. In one embodiment, the input image may comprise image of agricultural product placed on a plain background with a size-reference coin. In one embodiment, before capturing the image of the agricultural product, a sample (e.g., small quantity) of the agricultural product is collected. The sample is spread on the background having a different or contrasting color (for example, black, blue, or red color) than the color of agricultural product. In one embodiment, the background could be of multi-colored or any non-contrasting color. The image acquisition module 201 further processes the received input image to generate the sample image by removing background and other irregularities from the input image. In one embodiment, the image acquisition module 201 generates one or more sample images of agricultural product based on application of one or more compression techniques.

[0054] Further, the hybrid segmentation module 202 is configured to generate one or more segmented object images based on the application of a hybrid segmentation algorithm on the generated one or more sample images of the agricultural product. The hybrid segmentation algorithm is based on the selection of a type of agricultural product. The hybrid segmentation algorithm may include but is not limited to instance segmentation model, object detection model followed by semantic segmentation model, classical image processing, machine learning (ML) model and/or an artificial intelligence (AI) model and a combination thereof. In an embodiment, generation of one or more segmented object images may comprise steps of rejecting one or more pixels of said one or more samples images, related to undesirable small particles such as dust with reference to an area of a size-reference coin which is placed along with the agricultural product in the sample images. The generation of one or more segmented object images may further generate the plurality of segmentation masks based on the application of instance segmentation on the sample images and generate the plurality of segmented object images based on the plurality of

segmentation masks. In another embodiment, the generation of one or more segmented object images may generate one or more bounding boxes around the detected object (e.g., individual seed/grain of agricultural product) in the sample images and generate the plurality of segmentation masks based on one or more bounding boxes and further generate the plurality of segmented object images based on the plurality of segmentation masks. Various deep learning and classical image processing techniques may be used to generate precise segmentation masks. In one embodiment, a rotated object localization technique is used in combination with the above techniques to improve the accuracy of segmentation masks for generating the plurality of segmented object images.

[0055] Further, the hybrid classification module 203 is configured to determine one or more classes of the agricultural product based on application of a hybrid classification algorithm on the segmented object images of the agricultural product. The hybrid classification algorithm further comprising a machine learning (ML) model and/or an artificial intelligence (AI) model and a combination thereof. ML and AI include training dataset related to generalized features of agricultural product including at least one of color, shape, size, or texture-based features. The hybrid classification module further determines one or more classes of for plurality of segmented object images by weighted score on the generalized feature scores and dynamically predicting one class among said determined one or more classes based on application of AI model. The AI model may include but not limited to any Neural network model, like Convolutional Neural Network (CNN), Artificial Neural Network (ANN), Deep Neural Network (DNN) etc. In one embodiment, an improved AI model such as adaptive multi-nodal CNN model may be used. In one embodiment, the AI model is trained with temperature scaling technique to penalize more on the wrong prediction. In one embodiment, hybrid classification module may further comprise a step of optimizing one or more loss functions to effectively perform machine learning. To optimize one or more loss functions, an efficient procedure of simultaneous loss minimization (by seeking parameters that lie in neighborhoods having uniformly low loss value) is applied, resulting in better generalization and reduction in overfitting. In one embodiment, Anti distortion technique is used to improve the robustness of hybrid classification algorithm.

[0056] Further, the physical parameter distribution module 204 determines feature scores related to one or more physical features of said agricultural product and generate physical parameter distribution graphs indicating different variations of physical features in the sample images of the

agricultural product. The feature scores related to one or more physical feature of the agricultural product include, but not limited to, shape, texture, lustre, an average kernel/grain size, an aspect ratio index, a profile index, a size uniformity, moisture, an average grain height, a core index, a color index or other related visual features. The APQA system 101 generate the quality assessment information of the agricultural product based on feature scores and physical parameter distribution information. Further, the APQA system 101 configured to control a display to show various results such as input images, sample image, bounding boxes, segmentation masks, segmented object image, image with classes, physical parameter distribution information along with quality assessment information of agricultural product.

[0057] In one embodiment, The APQA system 101 calculate pricing information of agricultural product. The pricing information of agricultural product is based on quality assessment information, geographic location of place producing and/or selling agricultural product and market pricing information of agricultural product. In one embodiment, The APQA system 101 consider external sensor data such as moisture, weight or any other data related to agricultural product, in combination with quality assessment information to determine pricing information of agricultural product.

[0058] In one embodiment, the APQA system 101 is portable and configurable in terms of quality parameters and/or feature scores which can be specific to procuring authority. In one embodiment, the APQA system 101 may generate configurable test report and statistical data based on one or more feature scores related to various physical features of agricultural product and physical parameter distribution information. In one embodiment, the APQA system 101 is configurable to send test report and statistical data to server, laboratory, or concern authority through any communication channel (e.g., mail, messaging platform etc.) when connected to internet and to print / fax when offline or to transfer files in any computing device of concern authorities (for example a laboratory in any industrial use case or any other use case).

[0059] Fig. 3 illustrates a flow diagram of a method of assessment of quality of agricultural product in accordance with one embodiment of the present invention.

[0060] As illustrated in Fig. 3, the method 300 comprises one or more steps implemented by the processor 102 for quality assessment of agricultural product. The method 300 may be described in the general context of computer executable instructions by the system 101. Generally, computer

executable instructions can include routines, programs, objects, components, data structures, procedures, modules, and functions, which perform particular functions or implement particular abstract data types. The order in which the method 300 is described is not intended to be construed as a limitation, and any number of the described method steps can be combined in any order to implement the method 300. Additionally, individual steps may be deleted from the method 300 without departing from the spirit and scope of the subject matter described herein. Furthermore, the method 300 can be implemented in any suitable hardware, software, firmware, or combination thereof.

[0061] At step 301, the method 300 comprises receiving from I/O interface 205, user inputs indicating a selection of a type of an agricultural product. The type of agricultural product may include but not limited to, different shapes, color, name such as corn, wheat etc. and category of commodities like legumes, beans, grains, kernels, oilseed, dry-fruits, pulses, nuts, seeds and any related agricultural crop.

[0062] At step 302, the method 300 comprises receiving from image sensors, input images of agricultural product. The input images may be captured after placing a sample of agricultural product on plain color surface with a size-reference coin.

[0063] At step 303, the method 300 comprises generating sample images of agricultural product based on received input images of agricultural product. The sample image is generated from received input image by modifying one or more image properties includes but not limited to pixel density, aspect ratio, size, dimension, resolution, brightness, sharpness etc. In one embodiment, one or more compression technique is used to modify the image properties.

[0064] At step 304, the method 300 comprises generating segmented object images based on application of a hybrid segmentation algorithm.

[0065] At step 305, the method 300 comprises determining classes of agricultural product based on application of a hybrid classification algorithm on segmented object images.

[0066] At step 306, the method 300 comprises determining feature scores related to physical features of agricultural product.

[0067] At step 307, the method 300 comprises generating physical parameter distribution information indicating different variations of physical features of agricultural product.

[0068] At step 308, the method 300 comprises generating quality assessment information of agricultural product based on feature scores and physical parameter distribution information.

[0069] Fig. 4 illustrates images at the various stages of the method according to one of the embodiments of the present invention. Fig. 4A shows the captured image of sample of agricultural product. Fig. 4B represents the image of sample of agricultural product along with segmentation masks and Fig. 4C represents the processed image of sample of agricultural product.

[0070] Fig. 5 illustrates various classified images of agricultural product based on application of a hybrid classification algorithm on the segmented object images in accordance with an example embodiment of the present invention. Further, all the object images are classified further and represented in separate classes. Exemplary Table 1 below depicts the quality score statistics of the sample of agricultural product (i.e., corn) generated by the APQA system.

Particulars	**Count Value**	**% Count**
Total kernel counts	219	100%
No Defect Kernel	194	88.6%
Mold Kernel	3	1.4%
Insect Kernel	12	5.5%
Foreign Kernel	4	1.8%
Broken Kernel	6	2.7%

Exemplary Table 1

[0071] After detecting defect and no defect kernels in the sample image, the different physical parameter distributions of the agricultural product such as graphs, histograms and indexes show the visual physical feature distribution of kernels based on shape, size, height, width, color, uniformity, endosperm region, luster etc. The physical parameter distribution information is essential to further analyze the quality of the sample of the agricultural product. These physical parameter distributions are also important for quality assessment for companies which require further processing of grains. For example, kernels having consistent/uniform size yields higher throughput in production. Additionally, many times kernels with particular shape and size are valued at higher market price.

[0072] Fig. 6 illustrates various graphs representing different physical parameter distributions of the agricultural product in accordance with an example embodiment of the present invention. Fig. 6A represents Kernel size distribution, Fig. 6B represents Endosperm size distribution, Fig. 6C shows Embryo size distribution, and Fig. 6D shows Kernel height distribution.

[0073] Fig. 7 illustrates graphs representing different physical parameter distributions of the agricultural product in accordance with an example embodiment of the present invention. Fig. 7A represents Aspect ratio distribution, Fig. 7B represents Kernel core distribution, Fig. 7C shows Endosperm profile distribution, and Fig. 7D shows yellow color index distribution. All the collected data are stored at the server and can be transferred in form of graphical representation to the user device.

[0074] It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-discussed embodiments may be used in combination with each other. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description.

[0075] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0076] The benefits and advantages which may be provided by the present invention have been described above with regard to specific embodiments. These benefits and advantages, and any elements or limitations that may cause them to occur or to become more pronounced are not to be construed as critical, required, or essential features of any or all of the embodiments.

[0077] While the present invention has been described with reference to particular embodiments, it should be understood that the embodiments are illustrative and that the scope of the invention is not limited to these embodiments. Many variations, modifications, additions and improvements to the embodiments described above are possible. It is contemplated that these variations, modifications, additions and improvements fall within the scope of the invention.

We claim:

1. A method for quality assessment of an agricultural product, the method comprising:

receiving one or more inputs indicating a selection of a type of said agricultural product;

receiving one or more input images of said agricultural product from one or more image sensors;

generating one or more sample images of said agricultural product based on application of one or more compression techniques on said received one or more input images;

generating one or more segmented object images based on application of a hybrid segmentation algorithm on said generated one or more sample images of said agricultural product, wherein said application of hybrid segmentation algorithm is based on said selection of said type of agricultural product;

determining one or more classes of said agricultural product based on application of a hybrid classification algorithm on said one or more segmented object images of said agricultural product;

determining one or more feature scores related to one or more physical features of said agricultural product, based on said determined one or more classes of said agricultural product;

generating physical parameter distribution information indicating different variations of said one or more physical features in said generated one or more sample images of said agricultural product;

generating quality assessment information of said agricultural product based on said determined one or more feature scores and said generated physical parameter distribution information; and

controlling an output device to render the generated quality assessment information of said agricultural product.

2. The method of claim 1, further comprising calculating pricing information of said agricultural product, based on said generated quality assessment information and market pricing information of said agricultural product.

3. The method of claim 1, wherein said generation of one or more segmented object images, further comprising:

rejecting one or more pixels of said one or more samples images, related to undesirable small particles, based on an area of a size-reference coin which is placed along with said agricultural product in said one or more sample images.

generating plurality of segmentation masks based on application of instance segmentation on said one or more sample images; and

generating said one or more segmented object images based on said generated plurality of segmentation masks.

4. The method of claim 1, wherein said generating one or more segmented object images, further comprising:

generating one or more bounding box in said one or more sample images based on application of a trained object detection model on said one or more sample images;

generating plurality of segmentation masks based on said generated one or more bounding boxes; and

generating said one or more segmented object images based on said generated plurality of segmentation masks.

5. The method of claim 1, wherein the hybrid classification algorithm further comprising at least a machine learning model or an artificial intelligence model and a combination thereof for:

training dataset related to generalized features of agricultural product including at least one of color, shape, size, or texture;

determining one or more classes of said one or more segmented object images by weighted score on said generalized features; and

dynamically predicting one class among said determined one or more classes based on application of an adaptive multi-nodal CNN model.

6. The method of claim 1, wherein the feature scores related to said one or more physical feature of said agricultural product include at least one of shape, texture, lustre, an average kernel/grain size, an aspect ratio index, a profile index, a size uniformity, moisture, an average grain height, a core index, a color index or other related visual features.

7. The method of claim 1, wherein the quality assessment of agricultural product is performed offline or online.

8. The method of claim 1, further comprising generating configurable test report and statistical data based on said determined one or more feature scores related to one or more physical feature of said agricultural product and said generated physical parameter distribution information.

9. The method of claim 1, wherein said agricultural product comprises at least one of legumes, beans, grains, cereals, kernels, oilseed, dry-fruits, pulses, nuts, seeds and any related agriculture crops.

10. An agricultural product quality assessment (APQA) system, the system comprising:

one or more processors,

one or more image sensors coupled with said one or more processors, and

a memory storage communicatively coupled with said one or more processors, wherein said memory stores processor-executable instructions, which on execution cause said one or more processors to:

receive one or more inputs indicating a selection of a type of an agricultural product;

receive one or more input images of said agricultural product from one or more image sensors;

generate one or more sample images of said agricultural product based on application of one or more compression techniques on said received one or more input images;

generate one or more segmented object images based on application of a hybrid segmentation algorithm on said generated one or more sample images of said agricultural product, wherein said application of hybrid segmentation algorithm is based on said selection of said type of agricultural product;

determine one or more classes of said agricultural product based on application of a hybrid classification algorithm on said one or more segmented object images of said agricultural product;

determine one or more feature scores related to one or more physical features of said agricultural product, based on said determined one or more classes of said agricultural product;

generate physical parameter distribution information indicating different variations of said one or more physical features in said generated one or more sample images of said agricultural product;

generate quality assessment information of said agricultural product based on said determined one or more feature scores and said generated physical parameter distribution information; and

control an output device to render the generated quality assessment information of said agricultural product.

11. The system of claim 10, wherein based on said execution of said processor-executable instructions, said one or more processors further:

calculate pricing information of said agricultural product, based on said generated quality assessment information and market pricing information of said agricultural product.

12. The system of claim 10, wherein for said generation of one or more segmented object images, the one or more processors further configured to:

reject one or more pixels of said one or more samples images, related to undesirable small particles, based on an area of a size-reference coin which is placed along with said agricultural product in said one or more sample images;

generate plurality of segmentation masks based on application of instance segmentation on said one or more sample images; and

generate said one or more segmented object images based on said generated plurality of segmentation masks.

13. The system of claim 10, wherein for said generation of one or more segmented object images, the one or more processors further configured to:

generate one or more bounding box in said one or more sample images based on application of a trained object detection model on said one or more sample images;

generate plurality of segmentation masks based on said generated one or more bounding boxes; and

generate said one or more segmented object images based on said generated plurality of segmentation masks.

14. The system of claim 10, wherein the hybrid classification algorithm further comprising at least a machine learning model or an artificial intelligence model and a combination thereof, the one or more processors further configured to:

train dataset related to generalized features of agricultural product including at least one of color, shape, size, or texture;

determine one or more classes of said one or more segmented object images by weighted score on said generalized features; and

dynamically predict one class among said determined one or more classes based on application of an adaptive multi-nodal CNN model.

15. The system of claim 10, wherein the feature scores related to said one or more physical feature of said agricultural product include at least one of shape, texture, lustre, an average kernel/grain size, an aspect ratio index, a profile index, a size uniformity, moisture, an average grain height, a core index, a color index, or other related visual features.

16. The system of claim 10, wherein said agricultural product comprise at least one of legumes, beans, grains, cereals, kernels, oilseed, dry-fruits, pulses, nuts, seeds and any related

agriculture crops.

17. The system of claim 10, wherein based on said execution of said processor-executable instructions, said one or more processors further:

receive one or more inputs related to requirement information of a procuring authority; and configure information related to one or more physical feature of said agricultural product as per the requirement information of said procuring authority.

18. The system of claim 10, wherein based on said execution of said processor-executable instructions, said one or more processors further transmit test report and statistical data to a server.

19. The system of claim 10, wherein said one or more input images are captured at multiple angles by said one or more image sensors to generate a wide-angle view of said agricultural product.

20. A non-transitory computer readable medium having stored thereon computer executable instruction which when executed by one or more processors, cause the one or more processors to carry out operations for quality assessment of an agricultural product, the operations comprising:

receiving one or more inputs indicating a selection of a type of said agricultural product;

receiving one or more input images of said agricultural product from one or more image sensors;

generating one or more sample images of said agricultural product based on application of one or more compression techniques on said received one or more input images;

generating one or more segmented object images based on application of a hybrid segmentation algorithm on said generated one or more sample images of said agricultural product, wherein said application of hybrid segmentation algorithm is based on said selection of said type of agricultural product;

determining one or more classes of said agricultural product based on application of a hybrid classification algorithm on said one or more segmented object images of said agricultural product;

determining one or more feature scores related to one or more physical features of said agricultural product, based on said determined one or more classes of said agricultural product;

generating physical parameter distribution information indicating different variations of said one or more physical features in said generated one or more sample images of said agricultural product;

generating quality assessment information of said agricultural product based on said determined one or more feature scores and said generated physical parameter distribution information; and

controlling an output device to render the generated quality assessment information of said agricultural product.

Dated this 23rd day of April 2022

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ABSTRACT

METHOD AND SYSTEM FOR QUALITY ASSESSMENT OF AGRICULTURAL PRODUCT

A method and system for quality assessment of agricultural product is provided herein. The agricultural product may be of different shapes, sizes and color. The method receives input images of agricultural product and a user input indicating a selection of a type of agricultural product. The method processes the received input images to generate sample images, segment the sample images by an application of a hybrid segmentation algorithm to create segmented object images. The application of hybrid segmentation algorithm is based on selection of type of agricultural product. The method further classifies the segmented object images by a hybrid classification module involving machine learning model, classical image processing, artificial intelligence model, and combination thereof. The method further determines feature scores related to physical features of agricultural product and preparing physical parameter distribution information. Further, quality assessment information of agricultural product is provided utilizing feature scores and physical parameter distribution information.

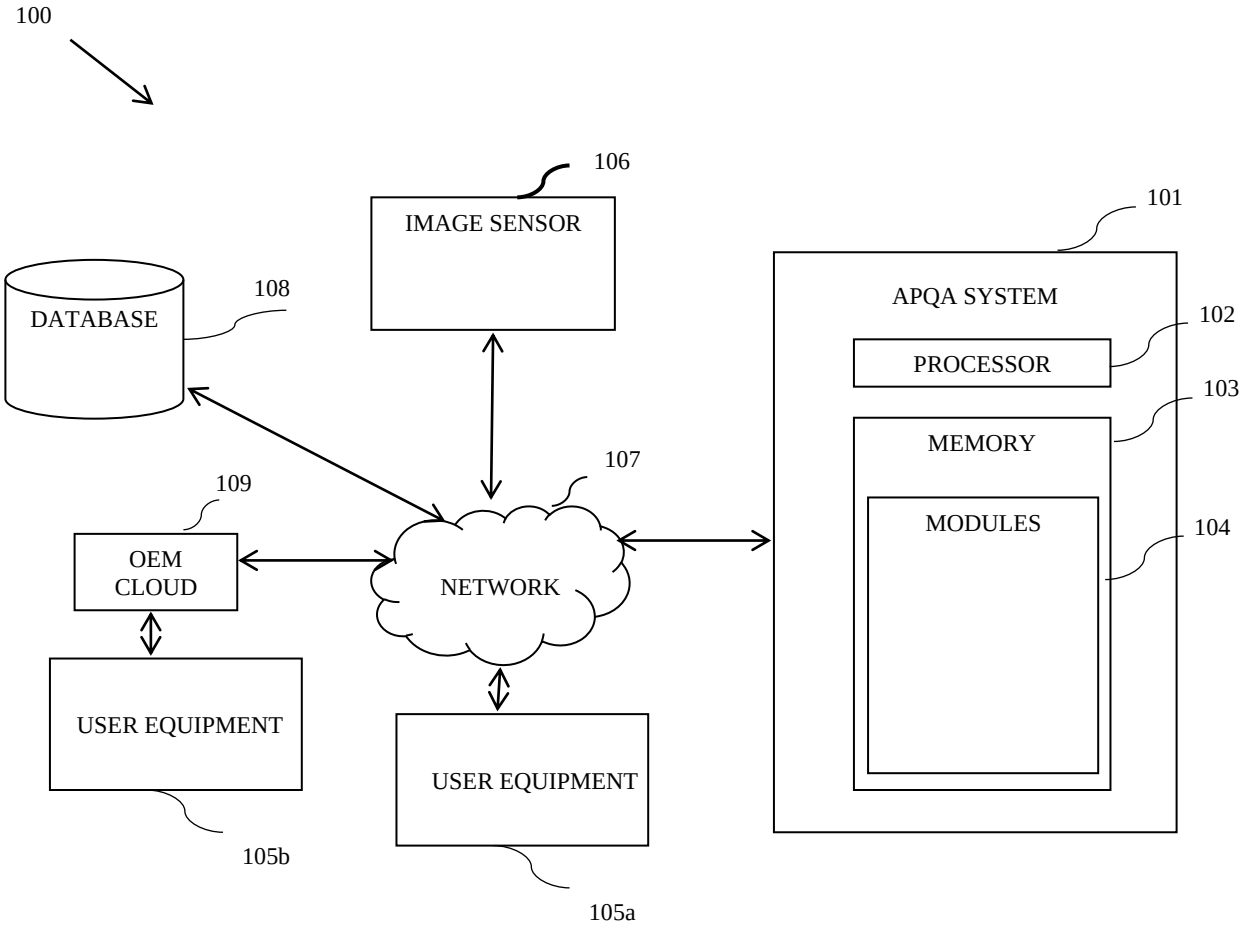

Fig. 1

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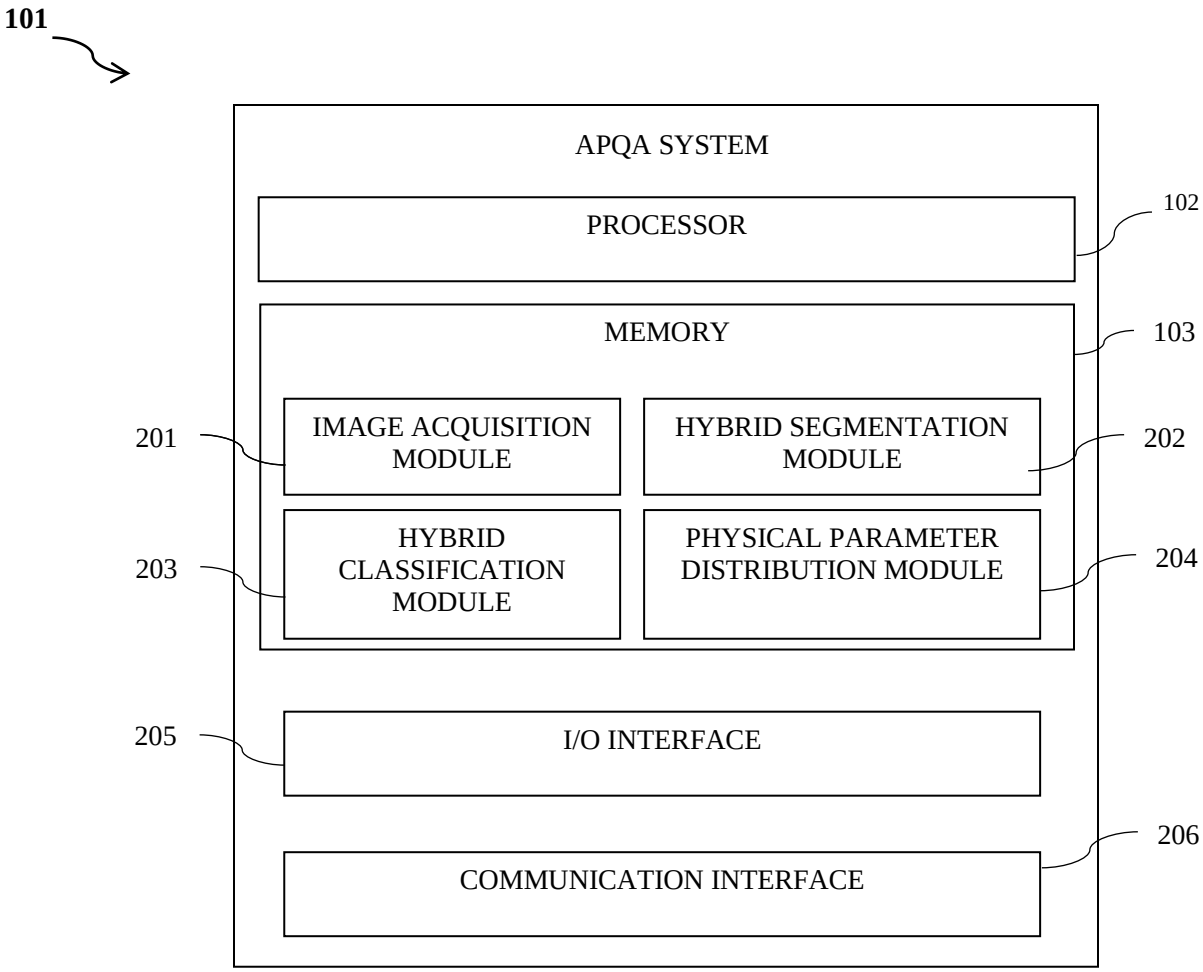

Fig. 2

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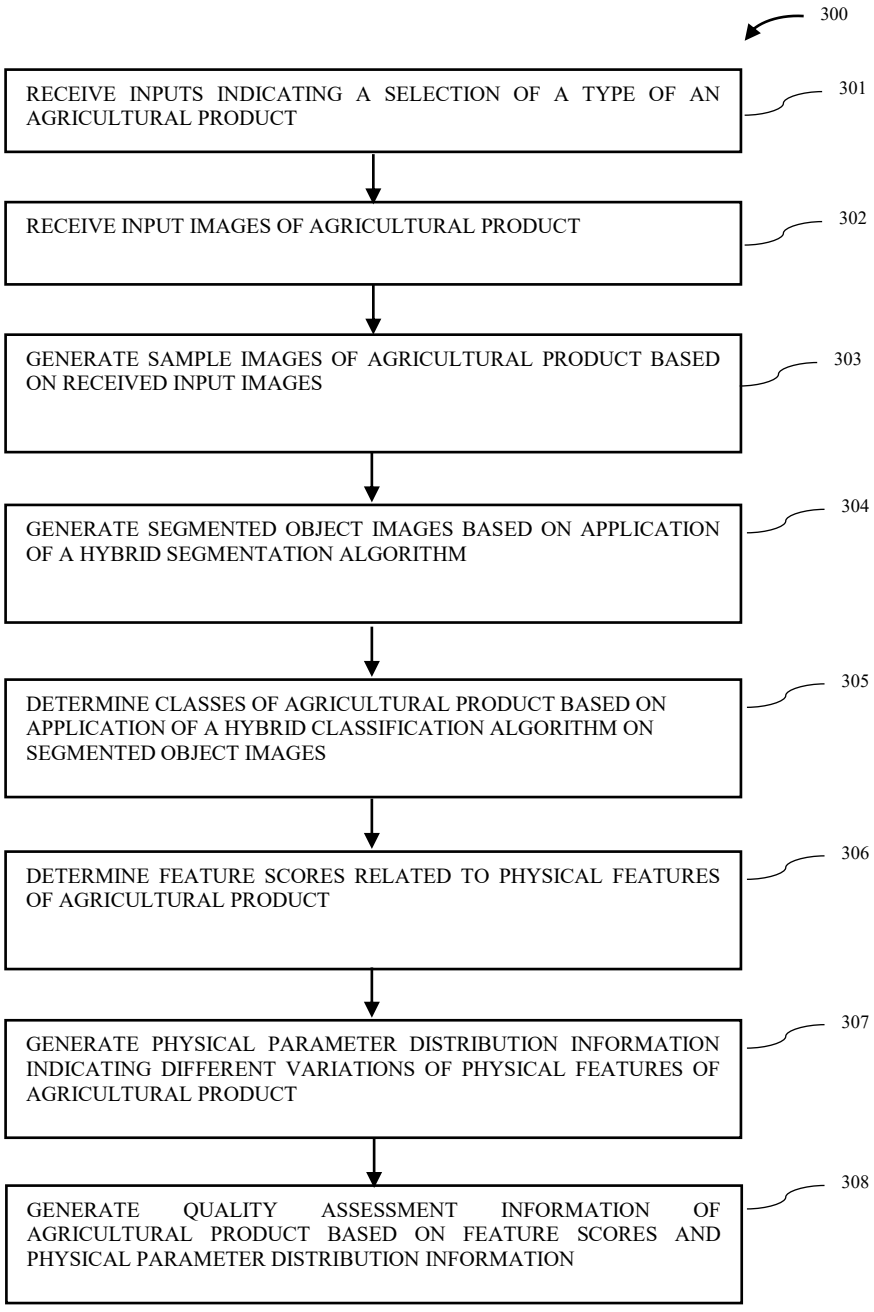

Fig. 3

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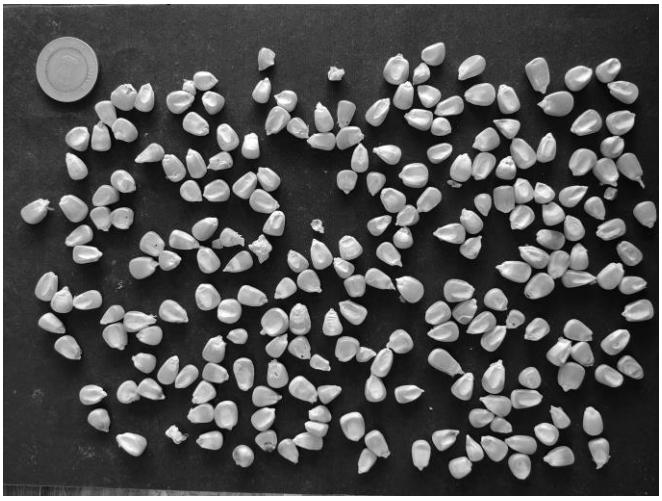

Fig. 4A

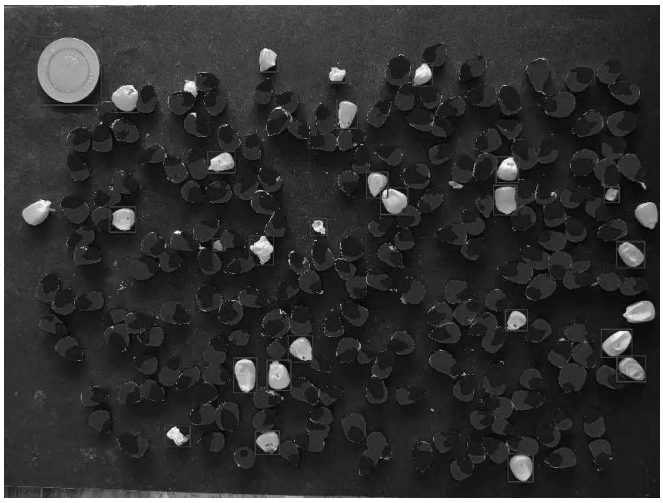

Fig. 4B

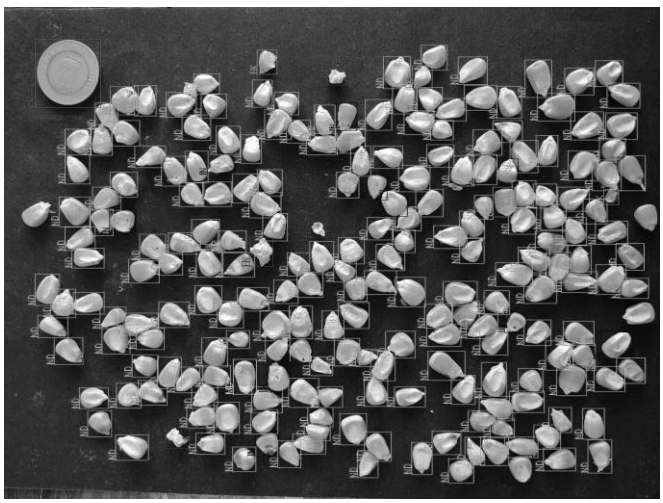

Fig. 4C

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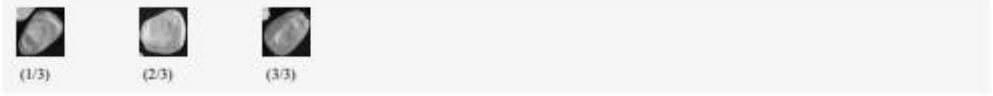
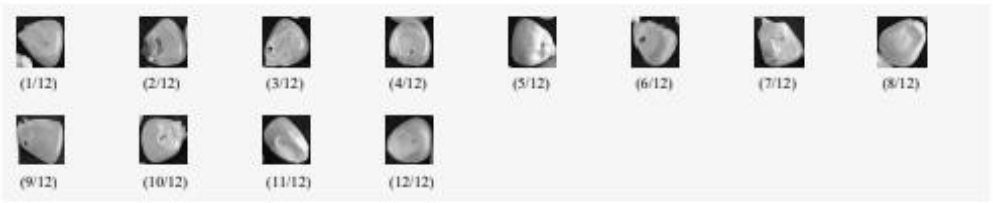
Kernel Type No Defect Kernel 194/219



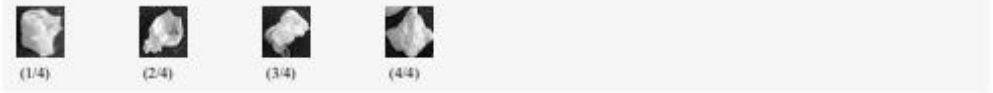
Kernel Type Mold Kernel 3/219



Kernel Type Insect Kernel 12/219



Kernel Type Foreign Kernel 4/219



Kernel Type Broken Kernel 6/219



Fig. 5

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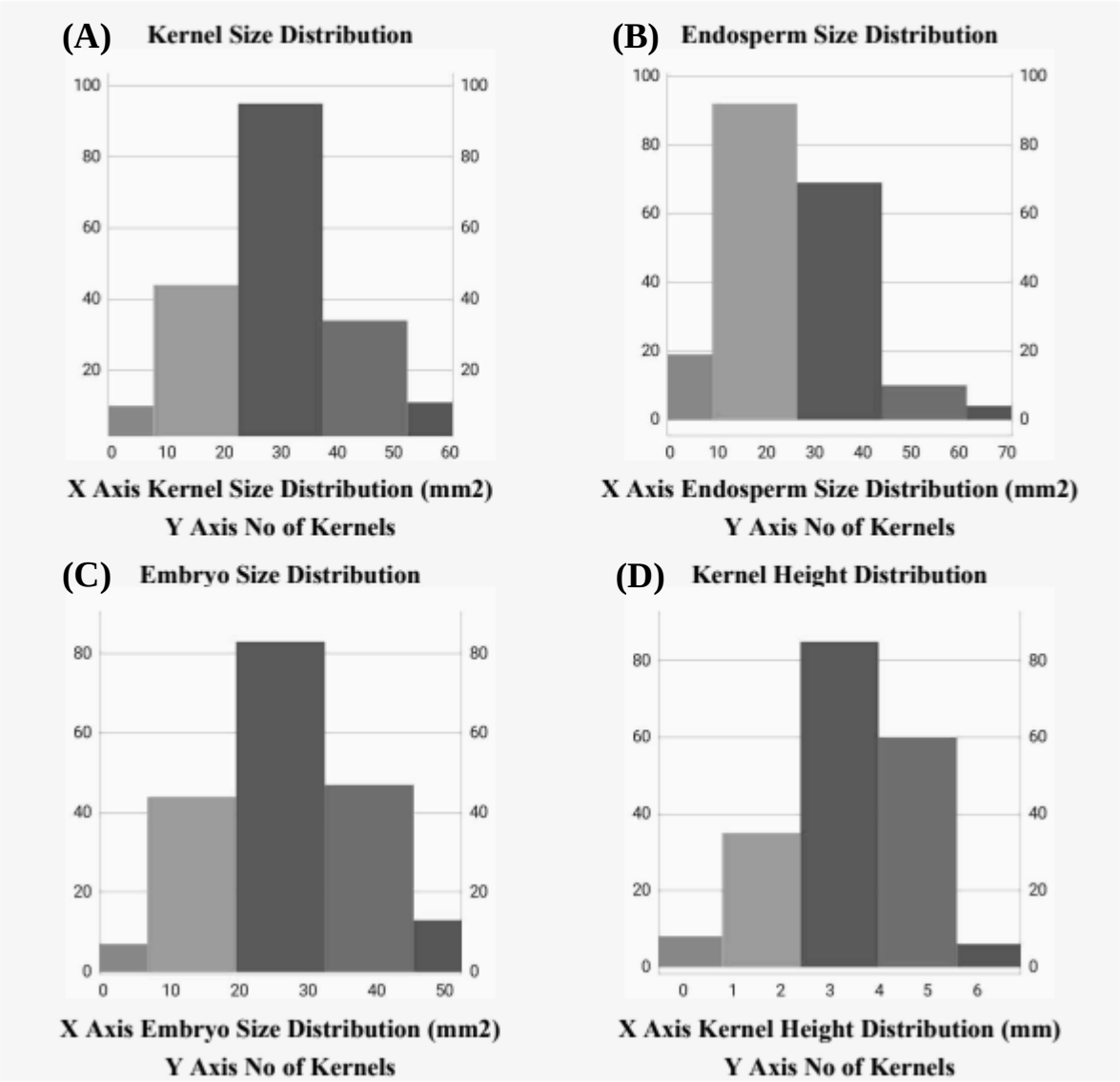

Fig. 6

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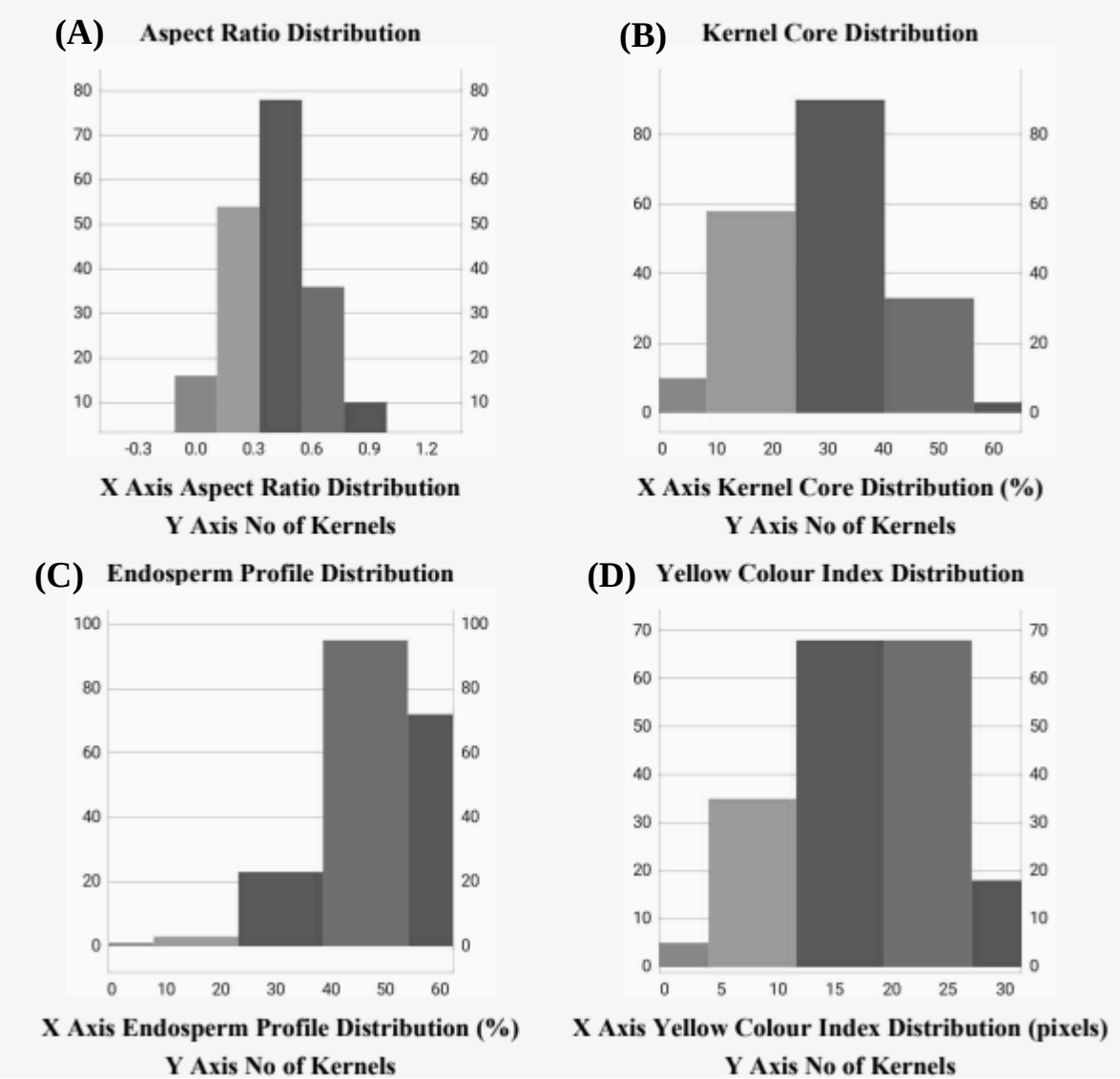

Fig. 7

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