United States Patent Application Publication 20250265890
Kind Code A1
Publication Date August 21, 2025
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PORTION CONTROL SYSTEM AND METHOD

Abstract

A portion control system includes an optical scanner, a cutting device, and a controller. The optical scanner generates a three-dimensional coordinate map of a bulk product disposed on a platform. The controller receives a target weight for a target portion to be excised from the bulk product. The controller determines a density of the bulk product and calculates a target volume of the target portion to be excised based on the target weight and the density. The controller determines, based at least on the three-dimensional coordinate map of the bulk product and the target volume, a cut path through the bulk product that is disposed on the platform, and controls the cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.

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Family ID: **1000007709075**

Appl. No.: **18/442981**

Filed: **February 15, 2024**

Publication Classification

Int. Cl.: **G07F13/04** (20060101)

U.S. Cl.:

CPC **G07F13/04** (20130101);

Background/Summary

FIELD

[0001] The subject matter herein relates to excising portions of bulk products via a computerized system for accurate portion control.

BACKGROUND

[0002] There are various application in which a portion of a bulk product is manually excised from the remainder of the bulk product in an attempt to ascertain an excised portion that has a desired, or target, weight. For example, deli counters and meat and seafood counters typically have a multitude of different food products available for customers. Some of the food products are too large for a typical customer to purchase and use, so the customer requests a vendor to excise a portion of the food product. The food product may be a fish, beef, lunch meat, cheese, prepared dishes (e.g., casseroles, salads, etc.), or the like. The customer may instruct the vendor which type of food product the customer desires and the target weight of the portion of the food product to buy. In the conventional process, the vendor extracts a first portion of the customer-selected food product, and then weighs the first portion on a weight scale. If the weight of the first portion is below the target weight, then the vendor may cut out a second portion of the food product to add to the first portion. If the first portion is above the target weight, the vendor may remove some of the material of the first portion and/or ask the customer if the excess amount is acceptable.

[0003] The vendor thus performs a manual guess-and-check process, using the weight of the excised portion as feedback, to narrow in on the target weight. This manual process is imprecise and inefficient. This manual process is dependent on the experience level of the vendor. Inexperienced vendors may require several cuts of the bulk product to reach the target weight. Furthermore, imprecise cuts from an inexperienced vendor may increase the amount of food or other bulk product that is wasted. The bulk products may have irregular shapes and/or non-uniform densities, so simple length measurements may not be effective to obtain accurate portion control.

[0004] Accordingly, a need exists for a more efficient and accurate system and method of providing portion control from a bulk product, particularly for use with bulk products that have irregular shapes and/or complex, non-uniform compositions.

SUMMARY

[0005] In one or more embodiments, a portion control system is provided that includes an optical scanner, a cutting device, and a controller that includes one or more processors. The optical scanner is configured to generate a three-dimensional coordinate map of a bulk product disposed on a platform. The controller is operably connected to the optical scanner and the cutting device. The controller is configured to receive a target weight for a target portion to be excised from the bulk product. The controller is configured to determine a density of the bulk product and to calculate a target volume of the target portion to be excised based on the target weight and the density. The controller is configured to determine, based at least on the three-dimensional coordinate map of the bulk product and the target volume, a cut path through the bulk product that is disposed on the platform, and to control the cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.

[0006] In one or more embodiments, a method for excising a portion of a bulk product is provided. The method includes receiving, at a controller including one or more processors, a target weight for a target portion to be excised from a bulk product. The method includes acquiring a three-dimensional coordinate map of the bulk product. The three-dimensional coordinate map is generated by an optical scanner while the bulk product is disposed on a platform. The method includes determining, via the controller, a density of the bulk product, and calculating a target volume of the target portion to be excised based on the target weight and the density. The method includes determining, via the controller and based at least on the three-dimensional coordinate map of the bulk product and the target volume, a cut path along the bulk product that is disposed on the

platform, and generating a control signal to control a cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a block diagram illustrating a portion control system formed in accordance with one or more embodiments.

[0008] FIG. **2** illustrates a portion control machine on which the portion control system is implemented according to an embodiment.

[0009] FIG. **3** illustrates a three-dimensional coordinate map of a bulk product shown in FIG. **2**.

[0010] FIG. **4** illustrates a diagram showing a template and the three-dimensional coordinate map of the bulk product.

[0011] FIG. **5** is a flow chart of a method for excising a target portion of a bulk product according to one or more embodiments.

DETAILED DESCRIPTION

[0012] Embodiments of the inventive subject matter describe a portion control system designed to provide efficient and accurate excision of portions of bulk products. The portion control system is a computerized system with automated operations. The portion control system is designed to receive information about desired characteristics of a portion of the bulk product to be excised, where the information includes at least a target weight of the portion. The portion control system analyzes properties of the bulk product, including the volume of the bulk product and the density of the bulk product. Based on this analysis, the portion control system determines a cut path through the bulk product. The portion control system then controls a cutting device to cut along the cut path and sever a target portion of the bulk product from the remainder of the bulk product. The portion control system is designed so that the severed target portion has approximately the target weight as requested. For example, the weight of the target portion that is actually excised from the bulk product may be within 2%, 1%, or even 0.5% of the target weight. This accurate portion control is accomplished using only a single cut (e.g., the cutting device following a single cut path) through the bulk product. The portion control system does not perform the imprecise guess-and-check process that is typically performed manually by a vendor. For example, the portion control system may not even weigh the target product after the target product is excised. The portion control system does not rely on the weight of the target product for feedback. Optionally, a vendor may choose to manually weigh the target product on a weight scale after the target product is produced for verifying to a customer that the target product has approximately the target weight.

[0013] One or more technical effects of the portion control system described herein include increased efficiency, as the portion control system may yield a target portion that has the target weight in less time than the traditional manual process of repeatedly cutting and then weighing the excised portion. Another technical effect may be enhanced accuracy, as the computerized system may generally provide more accurate target portions of a bulk product than a human vendor. Furthermore, the portion control system may desirably reduce labor costs by at least partially automating the process of excising portions of a bulk product, reducing the manpower needed for providing portion control. Another technical effect may be to reduce food waste, as the portion control system may make fewer cuts through the bulk product per target portion, on average, than a human vendor. For example, the portion control system is designed to excise each target portion of a bulk product using only a single cut path.

[0014] FIG. **1** is a block diagram illustrating a portion control system **100** formed in accordance with embodiments herein. The portion control system **100** includes a controller **102** that performs at least some of the operations described herein to provide portion control by excising a target portion from a bulk product. The controller **102** represents hardware circuitry that includes and/or is connected with one or more processors **104** (e.g., one or more microprocessors, integrated circuits, microcontrollers, field programmable gate arrays, etc.). The controller **102** includes and/or is connected with at least one tangible and non-transitory computer-readable storage medium (e.g., memory device) **106**. For example, the one or more processors **104** are communicatively connected to the at least one memory device **106**. The at least one memory device **106** may store programmed instructions (e.g., software) that are executed by the one or more processors **104** of the controller **102** to perform the operations of the controller **102** described herein. The programmed instructions may instruct the one or more processors **104** how to control the other components of the portion control system **100**. The programmed instructions may provide one or more algorithms that are performed by the one or more processors **104** as described herein. The memory device **106** may store additional information, such as a database **107** that contains a look-up table accessible to the one or more processors **104**.

[0015] The portion control system **100** includes additional components that are operably connected to the controller **102**. For example, the additional components may include an optical scanner **108**, a cutting device **110**, one or more input devices **112**, one or more output devices **114**, and a weight scale **116**. The additional components may be operably connected to the controller **102** via respective wired or wireless communication pathways. For example, the controller **102** may generate control signals that are communicated along the communication pathways to the additional components to control operation of the additional components. The controller **102** may receive information (e.g., data) from the additional components via the communication pathways. For example, the controller **102** may receive a three-dimensional coordinate map of a bulk product from the optical scanner. In another example, the controller **102** may receive a user input command from the user input device **112**. The user input command may indicate a target weight of a target portion of a bulk product to excise. The user input command may be generated by the user input device **112** in response to a user (e.g., a customer) manipulating the user input device **112**, such as by typing a message, pressing designated buttons, providing a voice command, and/or the like.

[0016] Optionally, the portion control system **100** may have at least one additional component that is not shown in FIG. **1**. For example, the portion control system **100** may include a spectrometer, an x-ray device, an ultrasound device, and/or a discrete camera (e.g., separate from the optical scanner). In another embodiment, the portion control system **100** may lack one or more of the additional components shown in FIG. **1**. For example, the portion control system **100** may lack the weight scale **116** and/or the output device(s) **114**, as described herein.

[0017] The optical scanner **108** scans a bulk product and generates a three-dimensional coordinate map of the bulk product. The optical scanner **108** may be a non-contact sensor that determines the relative locations of thousands or millions of individual points along the outer perimeter surface(s) of the bulk product. In an example, the optical scanner **108** may be a laser volumeter or a non-contact coordinate measuring machine (CMM). The optical scanner **108** assigns coordinates to the detected points in a coordinate field, where all points are relative to a point of origin in the coordinate field. The three-dimensional coordinate map is defined by the coordinates of the individual points that are detected by the optical scanner **108** during a scanning process. The three-dimensional coordinate map represents a virtual rendering of the bulk product.

[0018] The controller **102** receives the three-dimensional coordinate map from the optical scanner **108**, such as in the form of a scan file. The controller **102** may analyze the three-dimensional coordinate map of the bulk product. In an example, the controller **102** may determine a volume of the bulk product based on the size and shape of the three-dimensional coordinate map. In another example, the controller **102** may identify the type of bulk product based at least in part on the three-dimensional coordinate map. For example, the controller **102** may compare the shape and/or size of the bulk product, as represented in the three-dimensional coordinate map, to sizes and/or shapes of known products and identify the bulk product based on a level of correspondence or match with the known products. The sizes and/or shapes of the known products may be stored in a database, such as the database **107**, acquired via training of an artificial intelligence (AI) machine learning algorithm, or the like. The controller **102** uses the three-dimensional coordinate map of the bulk product to determine a cut path through the bulk product to excise or sever a target portion of the bulk product that has a target weight. For example, the controller **102** may analyze the three-dimensional coordinate map to determine coordinates of a cut path that will yield the target portion.

[0019] The cutting device **110** is controlled by the controller **102** to cut the bulk product along a determined cut path to sever a target portion of the bulk product from a remainder of the bulk product. After determining the cut path, the controller **102** may generate control signals, based on the coordinates of the cut path in the coordinate field, to control the cutting device **110** to cut the actual bulk product. For example, although there may be no physical cut path drawn or otherwise shown on the bulk product, the cutting device **110** may be controlled to follow the cut path that is defined along the virtual rendering of the bulk product in the three-dimensional coordinate map. In an example, the cutting device **110** includes a laser that pierces and cuts through the bulk product along the cut path. The cutting device **110** may include a scanning head that aims the laser to follow the cut path while the cutting device **110** itself remains fixed in a secured location on a portion control machine. In another example, the cutting device **110** includes a blade that physically pierces and cuts through the bulk product. The cutting device **110** may include an actuator and/or robotic arm that control the angle of the blade and the position of the blade in three (e.g., x, y, and z) dimensions. The actuator and/or robotic arm may be controlled to move the blade along the cut path to excise the target portion of the bulk product.

[0020] The one or more user input devices **112** may permit a human operator, such as a vendor, to interact with the portion control system **100**. A human operator may use an unput device **112** to submit a user input command that provides instruction to the controller **102** about a desired task. For example, a user input command may indicate a target weight of the target portion of the bulk product to be excised from the bulk product. In a food counter application, a customer may tell a vendor which product the customer is interested in purchasing and the target weight of that product. The vendor may then pick up the bulk product, place the bulk product on a platform of the portion control system **100**, and use one of the user input devices **112** to input the customer-selected target weight into the portion control system **100**. The user input device **112** may convey the information that is input by the vendor to the controller **102**. The controller **102** determines the cut path based on both the three-dimensional coordinate map of the bulk product and the target weight. The one or more input devices **112** may include physical buttons, a keyboard, virtual buttons on a touchscreen, a graphical user interface (GUI), a mouse, a microphone, or the like. Optionally, the operator may use the one or more input devices **112** to provide additional information to the controller **102**, such as to identify the type of the bulk product that is selected and/or a specific request of the customer. The specific request may indicate a segment or composition of the bulk product that is requested by the customer to be included in the target portion, a segment or composition of the bulk product that is to be avoided in the target portion, or the like. For example, a customer may prefer a specific designated cut of meat, a specific thickness of lunch meat slices, a lean portion of meat, a fatty portion of meat, or the like.

[0021] The one or more output devices **114** may be controlled by the controller **102** to provide information about the cutting process and/or the target portion of the bulk product that is excised. The one or more output devices **114** may include a printer that generates a label, a display screen, an audio speaker, and/or the like. For example, after cutting the target portion of the bulk product, the controller **102** may control the printer to print a label that provides information about the target portion. The information may include a type of the target portion and/or bulk product (e.g., salmon fillet), a weight of the target portion, a cost of the target portion, a cost per weight of the bulk product, a specific cut or other custom user selection provided to the vendor, and/or the like. The label may be secured to a package that contains the target portion. The label may have an adhesive backing. The display screen may display similar information. Optionally, the display screen may display an indication of a current status of the cutting process and/or may display the three-dimensional coordinate map of the bulk product.

[0022] The weight scale **116** is used to measure a weight of the bulk product. For example, the weight scale **116** may be integrated with a platform. The bulk product is placed on the platform and remains disposed on the platform during the scanning and cutting processes. The weight scale **116** may generate a sensor signal that is communicated to the controller **102**. The sensor signal generated by the weight scale **116** indicates a measured weight of the bulk product. The measured weight may be in units of grams or the like.

[0023] FIG. **2** illustrates a portion control machine **200** on which the portion control system **100** (shown in FIG. **1**) is implemented according to an embodiment. The portion control machine **200** includes a housing **202**. The housing **202** may contain and/or hold several components of the portion control system **102** in a fixed position. For example, the housing **202** holds the optical scanner **108** and the cutting device **110**. The housing **202** may contain the controller **102** within an internal portion of the housing **202**. In the illustrated example, the one or more input devices **112** and the one or more output devices **114** are secured on the housing **202**. For example, the portion control machine **200** may include a display screen **204**, a printer **206** that prints labels **208**, several physical buttons **210**, and a touchpad or touchscreen **212**. The specific types of input and output devices and the locations of the input and output devices shown in FIG. **2** merely indicate one example implementation of the portion control machine **200**.

[0024] The portion control machine **200** also includes a platform **214** that is secured to the housing **202**. The platform **214** receives the bulk product **216** on a top surface **218** of the platform **214**. In an example, the platform **214** may revolve **360** degrees about a central axis to spin the bulk product **216** relative to the housing **202** (and the optical scanner **108** and the cutting device **110** thereon). For example, the platform **214** may be mechanically connected to an actuator that is selectively controlled by the controller **102** to rotate the platform **214** during the scanning process and/or during the cutting process. The weight scale **116** may be integrated with the platform **214** to measure the weight of the bulk product **216** that is disposed on the platform **214**. The housing **202** may define a window **220**, which is an open space, above the platform **214** to accommodate the bulk product **216** without physically contacting the bulk product **216**.

[0025] In the illustrated example, the optical scanner **108** and the cutting device **110** are mounted at respective elevated positions relative to the platform **214**. In an example, the optical scanner **108** is laterally fixed in place, and the platform **214** rotates to enable the optical scanner **108** to scan the entire circumference of the bulk product **216**. The optical scanner **108** may be vertically movable relative to the housing **202** along a track defined along an upright section **222** of the housing **202**. The controller **102** may control vertical movement of the optical scanner **108** along the track, via an actuator, to enable the optical scanner **108** to scan both the top and bottom portions of the bulk product **216** for an accurate three-dimensional coordinate map. In an example, the cutting device **110** is a laser emitter **226** that emits a laser beam **224** to cut the target portion of the bulk product **216**. The laser emitter **226** may include a scanning head that aims the laser without requiring physical movement of the laser emitter **226** itself. Optionally, the laser emitter **226** may be physically movable along one or more dimensions relative to the housing **202** to permit the laser beam **224** to reach a greater percentage of the surface area of the bulk product **216** than if the laser emitter **226** is fixed in place. For example, the laser emitter **226** may be moved, during the cutting process, along a least one track in the housing **202** by an actuator that is controlled by the controller **102**.

[0026] An operator, such as a vendor, may use the portion control machine **200** to sever a target portion of the bulk product **216**, where the target portion has a weight that is approximately a user-selected target weight. The portion control machine **200** may excise the target portion of the bulk product **216** without measuring the weight of the target portion. For example, the portion control machine **200** does not cut a first portion of the bulk product **216**, then weigh the first portion, compare that weight of the first portion to the target weight, and then determine whether to cut a second portion of the bulk product **216** or remove part of the first portion based on a deviation between the weight of the first portion and the target weight.

[0027] The controller **102** receives a target weight for a target portion to be excised from the bulk product **216**. The operator may input the target weight using the one or more input devices **112**. For example, the operator may press one or more physical buttons **210** or virtual buttons on the touchscreen **212** to input the target weight. The target weight may be communicated to the operator from a user, such as a customer of the vendor.

[0028] Once the bulk product **216** is on the platform **214**, the controller **102** controls the optical scanner **108** to scan the bulk product **216** and generate a three-dimensional coordinate map of the bulk product **216**. FIG. **3** illustrates a three-dimensional coordinate map **302** of the bulk product **216** shown in FIG. **2**. The three dimensional coordinate map **302** is rendered in a coordinate field or system that includes a vertical axis **304**, a longitudinal axis **306**, and a lateral axis **308**, which are mutually perpendicular. The three-dimensional coordinate map **302** is a virtual rendering of the bulk product **216** that is generated by the optical scanner **108** scanning the bulk product **216** on the platform **214**.

[0029] Returning now to FIG. **2**, the controller **102** determines a density of the bulk product **216**. In a first example, the controller **102** calculates the density of the bulk product **216** based on the weight of the bulk product **216** and the volume of the bulk product **216**. For example, the weight of the bulk product **216** may be measured by the weight scale **116** while the bulk product **216** is on the platform **214**. The controller **102** receives a weight value representing the weight of the bulk product **216** from the weight scale **116**. In an alternative embodiment, the portion control machine **200** lacks the weight scale **116**, and the operator places the bulk product **216** on a separate weight scale to measure its weight. The controller **102** may determine the volume of the bulk product **216** based on the three-dimensional coordinate map generated by the optical scanner **108**. For example, the controller **102** may use the coordinates of the points to integrate the dimensions of the bulk product and calculate the volume of the bulk product **216**. The controller **102** may determine the density of the bulk product **216** by dividing the weight (e.g., mass) by the volume.

[0030] In another example, the controller **102** may determine an identity of the bulk product **216** and then access a look-up table to acquire a stored density value for the specific bulk product **216**. Thus, the controller **102** may essentially look-up the density for the bulk product **216** without actually calculating the density. There are multiple ways in which the controller **102** may determine the identity of the bulk product **216**. In a first example, the one or more input devices **112** may include a reader device, such as an RFID reader, a barcode or QR code scanner, or the like. The operator may acquire an RFID tag, barcode, QR code, or the like that is associated with the bulk product that is selected, and may scan the RFID tag, barcode, QR code, etc. via the reader device. The reader device then communicates a signal to the controller **102** that indicates the identity of the bulk product. The controller **102** may receive the signal from the reader device and determine the identity of the bulk product **216**. The identity may refer to the type of bulk product **216**, such as a type of meat, a type of prepared dish, etc. The identity optionally may indicate a specific manufacturer or brand associated with the bulk product **216**.

[0031] In a second example, the controller **102** may determine the identity of the bulk product **216** based on an analysis of visual characteristics of the bulk product **216**. For example, the controller **102** may analyze the size and shape of the bulk product as represented in the three-dimensional coordinate map. The controller **102** may compare the size and shape of the bulk product in the three-dimensional coordinate map to pre-determined sizes and shapes of known types of bulk products. The pre-determined sizes and shapes of the known types of bulk products may be stored in a database, such as the database **107**. The controller **102** may determine a level of correspondence or match between the measured sized and shape of the bulk product **216** on the platform **214** and the pre-determined sizes and shapes of the known types. If the level of correspondence with a first type of the known types exceeds a threshold value, such as 90%, 95%, or the like, the controller **102** may identify the bulk product **216** on the platform **214** as the first type.

[0032] In another example, the controller **102** may include an AI machine learning algorithm that is trained to determine the identity of the bulk product **216** based on the visual characteristics of the bulk product **216**. For example, the AI machine learning algorithm may be trained via hundreds of labeled training images to distinguish between different types of bulk products that may be placed on the platform **214**. The AI machine learning algorithm may include an artificial neural network. The AI machine learning algorithm may analyze the size and shape of the bulk product **216** as represented in the three-dimensional coordinate map. Optionally, the optical scanner **108** may capture color and/or other parameters of the bulk product **216**, besides the size and shape. In that case, the AI machine learning algorithm may analyze the color of the bulk product **216** to determine the identity of the bulk product. Optionally, the portion control system **100** (and portion control machine **200**) may include a separate camera or spectrometer that generates image data (e.g., acquires or captures the image data based on light in the surrounding environment) of the bulk product **216** on the platform **214**, where the image data depicts the color of the bulk product **216** in the visual wavelength spectrum. The AI machine learning algorithm may receive the image data generated by the separate camera and/or spectrometer to determine the identity of the bulk product **216**.

[0033] The various examples above describe that the controller **102** can determine the identity of the bulk product **216** on the platform **214**. The controller **102** may then use the identity to determine the density of the bulk product **216**. For example, the controller **102** may access a look-up table that is stored in the database **107** (shown in FIG. **1**) or a remote database. The look-up table may include a list of various bulk products and corresponding density values for each of the bulk products in the list. The controller **102** may use the determined identity of the bulk product **216** to determine the density value stored in the database **107** that is associated with that specific bulk product **216**.

[0034] In another example, the portion control system **100** (e.g., portion control machine **200**) may include a sensor device that directly measures the density of the bulk device **216**. For example, the portion control system **100** may include an X-ray device, an ultrasound device, or the like. The controller **102** may receive a measurement of the density of the bulk device **216** from such a sensor device.

[0035] Once the controller **102** has determined the density of the bulk device **216**, the controller **102** may calculate a target volume of the target portion of the bulk product to be excised based on the density and the target weight. For example, the controller **102** may divide the target weight by the density to calculate the target volume. The target volume represents the volume of the bulk product **216** to cut off to yield a portion of the bulk product **216** that has (approximately) the target weight. Thus, the operator may input the target weight based on a selection made by a customer, for example, and the controller **102** determines the target volume of the target portion to excise based in part on that target weight.

[0036] With reference to FIG. **3**, the controller **102** may determine a cut path **310** through the bulk product **216** that is disposed on the platform **214**. The controller **102** may determine the cut path **310** based on the three-dimensional coordinate map **302** and the target volume that is calculated. For example, the controller **102** may analyze the three-dimensional coordinate map **302** and select a cut path **310** that would sever a target portion **312** of the bulk product **216** that has the target volume. For example, the controller **102** may select a distance from an edge of the bulk product **216** at which to place the cut path **310** and a length of the target portion needed to achieve the target volume, using knowledge of the volume of the three-dimensional coordinate map **302**. In some examples, the cut path **310** may have a non-linear trajectory from an initial cut location to a final cut location on the bulk product **216**. For example, the cut path **310** may have one or more turns and/or curved segments.

[0037] One of the benefits of the portion control system **100** (e.g., the portion control machine **200**) is that it is applicable for use with irregularly-shaped objects. As shown in FIGS. **2** and **3**, the bulk product **216** may have an irregular shape. For example, the bulk product **216** may be asymmetric along at least one dimension. The bulk product **216** in several applications may be a food product. For example, the bulk product **216** may be a block of lunch meat, a portion of an animal (e.g., cow, pig, turkey, etc.), a fish, or the like. Due to the irregular shape, it is complex and difficult to estimate dimensions of a target portion to excise that would produce a target portion that has the target weight. The controller **102** uses the three-dimensional coordinate map **302** of the bulk product **216** to accurately determine the cut path **310** that would yield a target portion **310** having the target weight, regardless of whether the bulk product **216** has a regular shape or an irregular shape. In other examples, the bulk product may be other types of food products, such as prepared dishes (e.g., casseroles, pasta salads, potato salads, etc.). The bulk products that can be used with the portion control system **100** and machine **200** described herein are not limited to food products, however. The bulk product may be various other types of products in other applications.

[0038] After determining the cut path **310** on the three-dimensional coordinate map **302**, the controller **102** controls the cutting device **110** to cut the actual bulk product **216** along a line that corresponds to the cut path **310**. For example, the controller **102** may generate one or more control signals that are conveyed to the cutting device **110** and instruct the operation of the cutting device **110**. The control signals instruct the first cut location on the bulk product **216**, the direction at which the cutting device **110** is to cut, and/or a depth at which to cut the bulk product **216**. In the example shown in FIG. **2**, the laser emitter **226** is controlled by the controller **102** to emit laser beams **224** that impinge on the bulk product **216** along a prescribed cut path **320** that corresponds to (e.g., is the equivalent of) the cut path **310** on the three-dimensional coordinate map **302**. In another example, the cutting device **110** includes a cutting blade and an arm, and the controller **102** generates control signals to control the movement of the arm to automatically move the cutting blade to cut the bulk product **216** along the cut path **320**.

[0039] Once the cutting device **110** completes the cutting process, the target portion **312** of the bulk product **216** is severed from the remainder of the bulk product **216**. The operator may then package the target portion **312** and separately package and/or store the remainder of the bulk product **216**. The controller **102** may control the printer **206** to produce the label **208** that describes information about the target portion **312**. The label **208** may be affixed to the packaging of the target portion **312**. The information on the label **208** may include the type of product, a cost or price associated with the target portion **312**, a cost or price per weight of the bulk product **216**, the target weight of the target portion **312**, and/or the like. Optionally, the operator may choose to weigh the target portion **312** to confirm that the target portion **312** weighs approximately the target weight.

[0040] In one or more embodiments, the controller **102** may determine respective locations of internal constituent elements of the bulk product **216**, and may determine the cut path based in part on the locations of the internal constituent elements. For example, a bulk product that is meat may include various internal constituent elements within the bulk product that have different material compositions from one another. Example internal constituent elements can include bones, fat, fins, a tail, or the like. Furthermore, the internal constituent elements could include different designated cuts of meat from an animal, such as T-bone, porterhouse, top loin, and filet mignon as different cuts of beef.

[0041] The controller **102** may determine locations of such internal constituent elements in the bulk product **216**, and may use the locations as a factor in determining the cut path. For example, a user may desire for the target portion that is excised to omit (e.g., be free of) a first constituent element. In that case, the controller **102** may determine the cut path based on the location(s) of the first constituent elements so that the target portion that is excised is free of the first constituent element.

As an example, the first constituent element can be bones, fat, fins, or a tail. In another example, the user may desire for the target portion to include a second constituent element, such as fat. In that case, the controller **102** may determine the cut path so that the target portion that is excised includes more fat than another portion of the bulk product that could have been excised.

[0042] The internal constituent elements are typically not visible along the outer perimeter of the bulk product. In an example, the controller **102** may determine the respective locations of the internal constituent elements within the bulk product itself by first identifying the bulk product. The controller **102** may identify the bulk product using the techniques described above. In one example, the controller **102** may use the identity of the bulk product to access a template that is associated with and based on the bulk product. FIG. **4** illustrates a diagram showing a template **400** and the three-dimensional coordinate map **302** of the bulk product **216**. The controller **400** selects the template **400** from a memory device, such as the memory **106**, based on the identity of the bulk product **216**. The template **400** may be a digital rendering that indicates respective locations of various internal constituent elements **402** of the bulk product **215**. In FIG. **4**, the template **400** shows, as internal constituent elements **402**, bones **404**, a bone joint **406**, and fat **408**. The template **400** may be three-dimensional, or may be two-dimensional but able to be repositioned and rotated in three dimensions. The controller **102** may use the coordinate field to map or format the template **400** to align with the three-dimensional coordinate map **302** of the bulk product **216**, such that the internal constituent elements **402** align within the boundary of the three-dimensional coordinate map **302**. FIG. **4** shows a combined image **410** that represents the template **400** aligned with the three-dimensional coordinate map **302**. The internal constituent elements **402** appear to be superimposed on the three-dimensional coordinate map **302**. The controller **102** may use the coordinate positions of the internal constituent elements **402** and the types of the internal constituent elements **402** as a factor in determining the cut path. For example, in FIG. **4**, if a user (e.g., customer) indicates that the user would like a lean, boneless portion of meat, the controller **102** may determine a cut path **412** through the bulk product **216** that would yield a target portion **414** of meat that is free of bones **404** and the fat section **408**, while satisfying the target weight requirement.

[0043] In another, related example, instead of accessing a template **400**, the controller **102** may estimate respective locations of internal constituent elements of the bulk product based on the determined identity of the bulk product and an analysis of a size and shape of the three-dimensional coordinate map **302** of the bulk product. For example, the controller **102** can determine the size and orientation of the bulk product **216** based on the three-dimensional coordinate map **302**. The controller **102** may determine the relative types and locations of the internal constituent elements within the bulk product based on the identity of the bulk product. The controller **102** may use the orientation and the size of the bulk product on the platform **204** to determine the specific locations, sizes, and orientations of the internal constituent elements within the bulk product. The controller can then determine the cut path based on the target volume and these determined locations of the internal constituent elements of the bulk product, as described above with respect to FIG. **4**.

[0044] FIG. **5** is a flow chart **500** of a method for excising (e.g., cutting out) a target portion of a bulk product that has a target weight according to an embodiment. The method may be performed, in whole or in part, by the controller **102** of the portion control system **100** (e.g., the portion control machine **200**). Optionally, the method may include additional steps than shown in FIG. **5**, fewer steps than shown in FIG. **5**, and/or different steps than shown in FIG. **5**.

[0045] At step **502**, a target weight is received for a target portion to be excised from a bulk product. At step **504**, a three-dimensional coordinate map of the bulk product is acquired. The three-dimensional coordinate map may be generated by an optical scanner while the bulk product is disposed on a platform. At step **506**, a density of the bulk product is determined. Optionally, the density of the bulk product may be determined by first measuring a weight of the bulk product via a weight scale. The weight scale may be integrated with a platform on which the bulk product is placed. The method may include determining a volume of the bulk product based on the three-dimensional coordinate map of the bulk product. The density of the bulk product may be determined by calculating the density based on the weight of the bulk product and the volume of the bulk product. For example, the density is mass (or weight) divided by volume. Optionally, the density of the bulk product may be determined by first determining an identity of the bulk product. Then, the method includes accessing a look-up table that associates density values with different corresponding bulk products. The density may be determined by looking up the density value in the look-up table that corresponds to the specific bulk product that is identified. In another example, the density may be determined using a sensor device that measures the density directly.

[0046] At step **508**, a target volume of the target portion to be excised is calculated based on the target weight and the density. For example, the target volume is calculated by dividing the target weight by the density that is determined in step **506**.

[0047] At step **510**, a cut path is determined along the bulk product that is disposed on the platform. The cut path may be determined based at least on the three-dimensional coordinate map of the bulk product and the target volume that is calculated at step **508**. The cut path is determined to yield a severed target portion of the bulk produce that has the target volume. Optionally, the cut path may also be determined based on the determined (e.g., estimated) locations of one or more internal constituent elements of the bulk product. In an first example, the method may include determining an identity of the bulk product, and then accessing a template based on the identity of the bulk product. The template may indicate respective locations of internal constituent elements of the bulk product. The method may involve comparing the three-dimensional coordinate map of the bulk product to the template to estimate the locations of the internal constituent elements within the bulk product as sized and oriented on the platform. The cut path may be determined based in part on the locations of the internal constituent elements of the bulk product, such as to avoid a first internal constituent element in the target portion and/or to include a second internal constituent element in the target portion. In a second example, the method may include determining the identity of the bulk product and then analyzing a size and shape of the three-dimensional coordinate map of the bulk product to estimate respective locations of internal constituent elements of the bulk product based on the identity of the bulk product. The cut path may be determined based on both the target volume and the locations of the internal constituent elements of the bulk product, such as to avoid a first internal constituent element in the target portion and/or to include a second internal constituent element in the target portion.

[0048] At step **512**, a control signal is generated to control a cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product. Optionally, the method may include packaging the target portion that is severed and/or printing a label that provides information about the target portion.

[0049] In an embodiment, the optical scanner **108** shown in FIGS. **1** and **2** may be a laser volumeter. The laser volumeter uses a laser beam to detect the distance to the bulk product that is disposed on the platform to scan its shape. The laser volumeter provides a relatively quick, non-contact volume measurement. The measurement results may quantify the shape of the bulk product using actual units of length. In another embodiment, the optical scanner **108** may be a coordinate measuring machine (CMM). The CMM may include a high-definition complementary metal-oxide-semiconductor (CMOS) image sensor/camera. The CMOS image sensor may have a photodiode and a CMOS transistor switch for each pixel, allowing the pixel signals to be amplified individually. By operating a matrix of switches, the pixel signals can be accessed directly and sequentially. Each pixel may have a different respective amplifier. Length and volume measurements may be obtained directly from the acquired data. For example, the measurements may include geometric dimensioning and tolerancing (GD&T) measurements.

[0050] Further the disclosure comprises examples according to the following clauses:

[0051] Clause 1. A portion control system comprising: [0052] an optical scanner configured to

generate a three-dimensional coordinate map of a bulk product disposed on a platform; [0053] a cutting device; and [0054] a controller including one or more processors and operably connected to the optical scanner and the cutting device, the controller configured to: [0055] receive a target weight for a target portion to be excised from the bulk product, [0056] determine a density of the bulk product, [0057] calculate a target volume of the target portion to be excised based on the target weight and the density, [0058] determine, based at least on the three-dimensional coordinate map of the bulk product and the target volume, a cut path through the bulk product that is disposed on the platform, and [0059] control the cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.
[0060] Clause 2. The portion control system of Clause 1, further comprising a user input device operably connected to the controller and configured to receive a user input command that indicates the target weight of the target portion to be excised from the bulk product.
[0061] Clause 3. The portion control system of Clause 1 or Clause 2, further comprising a weight scale integrated with the platform and configured to measure a weight of the bulk product that is disposed on the platform.
[0062] Clause 4. The portion control system of Clause 3, wherein the controller is configured to determine a volume of the bulk product based on the three-dimensional coordinate map of the bulk product, and the controller is configured to determine the density of the bulk product by calculating the density based on the weight of the bulk product and the volume of the bulk product.
[0063] Clause 5. The portion control system of any of Clauses 1-4, wherein the controller is configured to determine an identity of the bulk product, and the controller is configured to determine the density of the bulk product by accessing a look-up table that associates density values with different corresponding bulk products.
[0064] Clause 6. The portion control system of any of Clauses 1-5, wherein the cutting device comprises at least one of a cutting blade or a laser that is controlled to cut the bulk product along the cut path.
[0065] Clause 7. The portion control system of any of Clauses 1-6, wherein the optical scanner is configured to generate the three-dimensional coordinate map of a food product as the bulk product.
[0066] Clause 8. The portion control system of any of Clauses 1-7, wherein the optical scanner is configured to generate the three-dimensional coordinate map of an irregularly shaped product as the bulk product.
[0067] Clause 9. The portion control system of any of Clauses 1-8, further comprising an output device configured to print a label, the controller configured to control the output device to print the label to indicate at least one of a type of the bulk product, the target weight for the target portion, or a price associated with at least one of the bulk product or the target portion.
[0068] Clause 10. The portion control system of any of Clauses 1-9, wherein the optical scanner is one of a laser volumeter or a non-contact coordinate measuring machine (CMM).
[0069] Clause 11. The portion control system of any of Clauses 1-10, wherein the controller is further configured to determine an identity of the bulk product, access a template based on the identity of the bulk product, and compare the three-dimensional coordinate map of the bulk product to the template, wherein the template indicates respective locations of internal constituent elements of the bulk product, wherein the controller is configured to determine the cut path based on the target volume and the locations of the internal constituent elements of the bulk product.
[0070] Clause 12. The portion control system of Clause 11, wherein the controller is configured to determine the cut path for the target portion to be excised to omit a first internal constituent element of the bulk product.
[0071] Clause 13. The portion control system of Clause 11, wherein the internal constituent elements comprise at least one of bones, fat, fins, or a tail.
[0072] Clause 14. The portion control system of Clause 11, wherein the bulk product is a portion of an animal and the internal constituent elements comprise different designated cuts of meat from the

animal.
[0073] Clause 15. The portion control system of any of Clauses 1-14, wherein the controller is further configured to determine an identity of the bulk product and to analyze a size and shape of the three-dimensional coordinate map of the bulk product to estimate respective locations of internal constituent elements of the bulk product based on the identity of the bulk product, wherein the controller is configured to determine the cut path based on the target volume and the locations of the internal constituent elements of the bulk product.
[0074] Clause 16. A method comprising: [0075] receiving, at a controller comprising one or more processors, a target weight for a target portion to be excised from a bulk product; [0076] acquiring a three-dimensional coordinate map of the bulk product, the three-dimensional coordinate map generated by an optical scanner while the bulk product is disposed on a platform; [0077] determining, via the controller, a density of the bulk product; [0078] calculating a target volume of the target portion to be excised based on the target weight and the density; [0079] determining, via the controller and based at least on the three-dimensional coordinate map of the bulk product and the target volume, a cut path along the bulk product that is disposed on the platform; and [0080] generating a control signal to control a cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.
[0081] Clause 17. The method of Clause 16, further comprising: [0082] measuring a weight of the bulk product disposed on the platform via a weight scale integrated with the platform; and [0083] determining a volume of the bulk product based on the three-dimensional coordinate map of the bulk product, wherein determining the density of the bulk product comprises calculating the density based on the weight of the bulk product and the volume of the bulk product.
[0084] Clause 18. The method of Clause 16 or Clause 17, further comprising: [0085] determining an identity of the bulk product, wherein determining the density of the bulk product comprises accessing a look-up table that associates density values with different corresponding bulk products.
[0086] Clause 19. The method of any of Clauses 16-18, further comprising: [0087] determining an identity of the bulk product; [0088] accessing a template based on the identity of the bulk product, wherein the template indicates respective locations of internal constituent elements of the bulk product; and [0089] comparing the three-dimensional coordinate map of the bulk product to the template, wherein determining the cut path is based on both the target volume and the locations of the internal constituent elements of the bulk product.
[0090] Clause 20. The method of any of Clauses 16-19, further comprising: [0091] determining an identity of the bulk product; and [0092] analyzing a size and shape of the three-dimensional coordinate map of the bulk product to estimate respective locations of internal constituent elements of the bulk product based on the identity of the bulk product, wherein determining the cut path is based on both the target volume and the locations of the internal constituent elements of the bulk product.
[0093] As used herein, the terms “processor” and “computer,” and related terms, e.g., “processing device,” “computing device,” and “controller” may be not limited to just those integrated circuits referred to in the art as a computer, but refer to a microcontroller, a microcomputer, a programmable logic controller (PLC), field programmable gate array, and application specific integrated circuit, and other programmable circuits. Suitable memory may include, for example, a computer-readable medium. A computer-readable medium may be, for example, a random-access memory (RAM), a computer-readable non-volatile medium, such as a flash memory. The term “non-transitory computer-readable media” represents a tangible computer-based device implemented for short-term and long-term storage of information, such as, computer-readable instructions, data structures, program modules and sub-modules, or other data in any device. Therefore, the methods described herein may be encoded as executable instructions embodied in a tangible, non-transitory, computer-readable medium, including, without limitation, a storage device and/or a memory device. Such instructions, when executed by a processor, cause the processor to

perform at least a portion of the methods described herein. As such, the term includes tangible, computer-readable media, including, without limitation, non-transitory computer storage devices, including without limitation, volatile and non-volatile media, and removable and non-removable media such as firmware, physical and virtual storage, CD-ROMS, DVDs, and other digital sources, such as a network or the Internet.

[0094] If a system, apparatus, assembly, device, etc. (e.g., a controller, control device, control unit, etc.) includes multiple processors, these processors may be located in the same housing or enclosure (e.g., in the same device) or may be distributed among or between two or more housings or enclosures (e.g., in different devices). The multiple processors in the same or different devices may each perform the same functions described herein, or the multiple processors in the same or different devices may share performance of the functions described herein. For example, different processors may perform different sets or groups of the functions described herein.

[0095] As used herein, the “one or more processors” may individually or collectively, as a group, perform these operations. For example, the “one or more” processors can indicate that each processor performs each of these operations, or that each processor performs at least one, but not all, of these operations.

[0096] Use of phrases such as “one or more of . . . and,” “one or more of . . . or,” “at least one of . . . and,” and “at least one of . . . or” are meant to encompass including only a single one of the items used in connection with the phrase, at least one of each one of the items used in connection with the phrase, or multiple ones of any or each of the items used in connection with the phrase. For example, “one or more of A, B, and C,” “one or more of A, B, or C,” “at least one of A, B, and C,” and “at least one of A, B, or C” each can mean (1) at least one A, (2) at least one B, (3) at least one C, (4) at least one A and at least one B, (5) at least one A, at least one B, and at least one C, (6) at least one B and at least one C, or (7) at least one A and at least one C.

[0097] As used herein, an element or step recited in the singular and preceded with the word “a” or “an” do not exclude the plural of said elements or operations, unless such exclusion is explicitly stated. Furthermore, references to “one embodiment” of the invention do not exclude the existence of additional embodiments that incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments “comprising,” “comprises,” “including,” “includes,” “having,” or “has” an element or a plurality of elements having a particular property may include additional such elements not having that property. In the appended claims, the terms “including” and “in which” are used as the plain-English equivalents of the respective terms “comprising” and “wherein.” Moreover, in the following claims, the terms “first,” “second,” and “third,” etc. are used merely as labels, and do not impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112(f), unless and until such claim limitations expressly use the phrase “means for” followed by a statement of function devoid of further structure.

Claims

1. A portion control system comprising: an optical scanner configured to generate a three-dimensional coordinate map of a bulk product disposed on a platform; a cutting device; and a controller including one or more processors and operably connected to the optical scanner and the cutting device, the controller configured to: receive a target weight for a target portion to be excised from the bulk product, determine a density of the bulk product, calculate a target volume of the target portion to be excised based on the target weight and the density, determine, based at least on the three-dimensional coordinate map of the bulk product and the target volume, a cut path through the bulk product that is disposed on the platform, and control the cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.

2. The portion control system of claim 1, further comprising a user input device operably connected to the controller and configured to receive a user input command that indicates the target weight of the target portion to be excised from the bulk product.
3. The portion control system of claim 1, further comprising a weight scale integrated with the platform and configured to measure a weight of the bulk product that is disposed on the platform.
4. The portion control system of claim 3, wherein the controller is configured to determine a volume of the bulk product based on the three-dimensional coordinate map of the bulk product, and the controller is configured to determine the density of the bulk product by calculating the density based on the weight of the bulk product and the volume of the bulk product.
5. The portion control system of claim 1, wherein the controller is configured to determine an identity of the bulk product, and the controller is configured to determine the density of the bulk product by accessing a look-up table that associates density values with different corresponding bulk products.
6. The portion control system of claim 1, wherein the cutting device comprises at least one of a cutting blade or a laser that is controlled to cut the bulk product along the cut path.
7. The portion control system of claim 1, wherein the optical scanner is configured to generate the three-dimensional coordinate map of a food product as the bulk product.
8. The portion control system of claim 1, wherein the optical scanner is configured to generate the three-dimensional coordinate map of an irregularly shaped product as the bulk product.
9. The portion control system of claim 1, further comprising an output device configured to print a label, the controller configured to control the output device to print the label to indicate at least one of a type of the bulk product, the target weight for the target portion, or a price associated with at least one of the bulk product or the target portion.
10. The portion control system of claim 1, wherein the optical scanner is one of a laser volumeter or a non-contact coordinate measuring machine (CMM).
11. The portion control system of claim 1, wherein the controller is further configured to determine an identity of the bulk product, access a template based on the identity of the bulk product, and compare the three-dimensional coordinate map of the bulk product to the template, wherein the template indicates respective locations of internal constituent elements of the bulk product, wherein the controller is configured to determine the cut path based on the target volume and the locations of the internal constituent elements of the bulk product.
12. The portion control system of claim 11, wherein the controller is configured to determine the cut path for the target portion to be excised to omit a first internal constituent element of the bulk product.
13. The portion control system of claim 11, wherein the internal constituent elements comprise at least one of bones, fat, fins, or a tail.
14. The portion control system of claim 11, wherein the bulk product is a portion of an animal and the internal constituent elements comprise different designated cuts of meat from the animal.
15. The portion control system of claim 1, wherein the controller is further configured to determine an identity of the bulk product and to analyze a size and shape of the three-dimensional coordinate map of the bulk product to estimate respective locations of internal constituent elements of the bulk product based on the identity of the bulk product, wherein the controller is configured to determine the cut path based on the target volume and the locations of the internal constituent elements of the bulk product.
16. A method comprising: receiving, at a controller comprising one or more processors, a target weight for a target portion to be excised from a bulk product; acquiring a three-dimensional coordinate map of the bulk product, the three-dimensional coordinate map generated by an optical scanner while the bulk product is disposed on a platform; determining, via the controller, a density of the bulk product; calculating a target volume of the target portion to be excised based on the target weight and the density; determining, via the controller and based at least on the three-

dimensional coordinate map of the bulk product and the target volume, a cut path along the bulk product that is disposed on the platform; and generating a control signal to control a cutting device to cut the bulk product along the cut path to sever the target portion from a remainder of the bulk product.

17. The method of claim 16, further comprising: measuring a weight of the bulk product disposed on the platform via a weight scale integrated with the platform; and determining a volume of the bulk product based on the three-dimensional coordinate map of the bulk product, wherein determining the density of the bulk product comprises calculating the density based on the weight of the bulk product and the volume of the bulk product.

18. The method of claim 16, further comprising: determining an identity of the bulk product, wherein determining the density of the bulk product comprises accessing a look-up table that associates density values with different corresponding bulk products.

19. The method of claim 16, further comprising: determining an identity of the bulk product; accessing a template based on the identity of the bulk product, wherein the template indicates respective locations of internal constituent elements of the bulk product; and comparing the three-dimensional coordinate map of the bulk product to the template, wherein determining the cut path is based on both the target volume and the locations of the internal constituent elements of the bulk product.

20. The method of claim 16, further comprising: determining an identity of the bulk product; and analyzing a size and shape of the three-dimensional coordinate map of the bulk product to estimate respective locations of internal constituent elements of the bulk product based on the identity of the bulk product, wherein determining the cut path is based on both the target volume and the locations of the internal constituent elements of the bulk product.