A non-contact sensing system for detecting a double feed condition of mail. The non-contact sensing system generally includes a mail sorting machine that routes and moves the mail, a non-contact sensor, and a controller. The non-contact sensor is positioned proximate to the conveyor and generates a signal that is indicative of the thickness of the mail. The controller receives the signal from the non-contact sensor and generates an output signal that indicates a double feed condition.
Input Max Envelope Length (MaxL) Min Envelope Length (MinL) Thickness profile for new mail piece (TP)

Length(TP) > MinL?

No

Return double feed confidence 0.

Yes

Are there at least three unique thickness points in TP?

No

Return double feed confidence 0.

Yes

Build an array of deltas between consecutive thickness values.

Is there a delta that matches the inverse of another delta?

No

Return double feed confidence 1.

Yes

Relate the beginning of the overlaid mail piece to delta (D1).
Relate the end of the other mail piece to delta (D2).

Calculate mail piece dimensions.

MailPiece1 = Length(TP) - D2
MailPiece2 = Length(TP) - D1

(MailPiece1<MinL) and (MailPiece2<MinL)

No

Return double feed confidence 1.

Yes

Return double feed confidence 2.

Fig. 3
204 Input thickness profile for new piece of mail.

208 Is there a "Historical" Thickness Profile?

   Yes

220 Does the new profile match the "historical" profile?

   Yes  → Return double feed confidence 0.
   No   → Generate expected double feed profile.

228 Does generated double feed profile match new profile?

   Yes  → Return double feed confidence 3.
   No   → Invalidate historical thickness profile. After "X" number of matching profiles, activate profile.

212 Add mail piece to beginning of a new historical profile.

216 Return double feed confidence 0.

Fig. 4
Input length of double feed profile to generate (L).

Is \((L \geq HPL)\) and \((L < 2HPL)\)?

Yes

Calculate the offset between images.
\[
\text{Offset} = L - HPL
\]

Generate an "add-on" thickness profile.

Combine the "add-on" thickness profile to the "historical" thickness profile to create the expected double feed profile.

Return generated double feed thickness profile.

Return empty or null double feed thickness profile.

Fig. 5
NON-CONTACT SENSING SYSTEM

BACKGROUND

[0001] The present invention relates to a non-contact sensor. More specifically, the present invention relates to a non-contact sensor that is applied in a mail sorting facility. Mail is sorted and delivered to locations all over the world every day. Often, mail is automatically processed by mail sorting equipment to expedite delivery. For example, a large stack of letters can be separated by a pick off feeder, which then feeds the separated letters into mail sorting equipment at a predetermined rate (e.g., 10-12 pieces per second) and with a predetermined pitch or letter separation (e.g., approximately two to three inches). In some instances, a “double feed” condition may occur, in which two pieces of mail are fed into the mail sorting equipment by the pick off feeder simultaneously and without the proper separation between each piece. The double feed can result in a mis-sorting of the mail pieces, because the mail sorting equipment downstream of the pick off feeder cannot properly recognize or track the double-fed mail.

SUMMARY

[0003] In one embodiment, a non-contact sensing system for detecting a double feed condition of mail includes a mail sorting machine having a conveyor, a non-contact sensor, and a controller. The mail sorting machine moves the mail, while the non-contact sensor is positioned proximate to the conveyor and generates a signal indicative of a thickness of the mail. The controller receives the signal from the non-contact sensor and generates an output signal indicative of a double feed condition.

[0004] In another embodiment, a method of calculating the likelihood of a double feed condition of mail includes generating a thickness profile for the piece of mail. The thickness profile is then compared to a historical thickness profile. The historical thickness profile is based on a previously generated thickness profile. Finally, a confidence value associated with the likelihood of a double feed condition is calculated. The confidence value is at least partially based on a comparison of the thickness profile to the historical thickness profile.

[0005] In another embodiment, a method of calculating the likelihood of a double feed condition of mail includes generating a thickness profile of the mail piece. A first distinct thickness and a second distinct thickness are then identified within the generated thickness profile of the mail. A transition between the first distinct thickness and the second distinct thickness is assigned a position value, and the thickness profile includes at least two position values. Finally, a double feed condition is identified based on the at least two position values.

[0006] In another embodiment, a method of generating a double feed thickness profile for detecting a double feed condition includes measuring the thickness and length of potentially overlapping pieces of mail with a non-contact sensor; generating a historical length that is based at least partially on previously measured lengths of mail; calculating an offset value between the potentially overlapping pieces of mail; and generating a thickness profile of the potentially overlapping pieces of mail that is based at least partially on the offset value.

[0007] Other aspects will become apparent by consideration of the detailed description and accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a block diagram of portions of a non-contact double feed detection system according to an embodiment of the invention.

[0009] FIG. 2A is a top schematic view of a non-contact double feed detection system according to an embodiment of the invention.

[0010] FIG. 2B is another top schematic view of a non-contact double feed detection system according to an embodiment of the invention.

[0011] FIG. 2C is yet another top schematic view of a non-contact double feed detection system according to an embodiment of the invention.

[0012] FIG. 3 is a flow diagram of one method of determining a double feed condition.

[0013] FIG. 4 is a flow diagram of another method of determining a double feed condition.

[0014] FIG. 5 is a flow diagram that generates a double feed thickness profile.

[0015] FIG. 6 schematically illustrates two overlapping pieces of mail having delta values applied to the mail edges.

[0016] FIG. 7A schematically illustrates two overlapping pieces of mail.

[0017] FIG. 7B schematically illustrates an add-on thickness profile for the overlapping pieces of mail shown in FIG. 7A.

DETAILED DESCRIPTION

[0018] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings.

[0019] FIG. 1 illustrates portions of a non-contact double feed detection system 10. The double feed detection system 10 includes a mail sorting machine 14 having at least one pulley or roller 18, an inner belt 22, and an outer belt 26, which can be used to move and/or sort mail 30. The double feed detection system 10 also includes a non-contact displacement sensor 34 having a sensing unit 38, a power communication cable 42, and a bracket 46. In other embodiments, the non-contact double feed detection system 10 may include more or fewer components than those shown in FIG. 1. For example, in an embodiment, as shown in FIGS.
2A-2C, an additional sensor can be added to the non-contact double feed detection system 10.

[0020] The mail sorting machine 14 can be configured to route and move the mail 30 through a mail sorting facility. In the embodiment shown in FIG. 1, the mail sorting machine 14 holds or pinches the mail 30 between the inner belt 22 and the outer belt 26. In some embodiments, the inner belt 22 and the outer belt 26 are relatively flexible, such that they bend around the edges of the mail 30, holding the mail 30 in position as it is transported through the mail sorting facility. The rollers 18 are used to support and drive the inner belt 22 and outer belt 26 at approximately equal speeds to move the pinched mail pieces 30. In other embodiments, the mail sorting machine 14 may include different rollers, belts, chains, conveyors, drive systems, and the like that are used to move mail 30 through the mail sorting facility.

[0021] As shown in FIG. 1, the sensing unit 38 of the displacement sensor 34 is positioned near the outer belt 26, and near the roller 18. The sensing unit 38 is secured in place by the bracket 46 and powered by the power/communication cable 42. By securing the sensing unit 38 near the roller 18, the roller 18 can provide a suitable and stable environment for taking displacement measurements. For example, the relatively hard surface of the roller 18 ensures that the inner belt 22 and the outer belt 26 will pass over the roller 18 without a significant amount of lateral movement which may otherwise compromise the accuracy of the measurements made by the sensing unit 38.

[0022] In operation, the sensing unit 38 transmits a signal toward the outer belt 26. The signal 50 is then reflected off of the outer belt 26 and returned to the sensing unit 38. Consequently, the sensing unit 38 can accurately measure and calculate the distance between the outer belt 26 and the sensing unit 38, as well as generate a corresponding output signal. The output signal can then be transmitted to a controller (as described in greater detail with respect to FIGS. 2A-2C) via the power/communication cable 42. In some embodiments, the sensing unit 38 is a photorelectric or laser sensor (e.g., a Baumer OADM 1216460/S35A photorelectric array sensor) that transmits and receives a focused beam of light (e.g., a laser), and generates a corresponding analog signal that is proportional to the reflection distance of the light. In other embodiments, the sensing unit 38 may be another reflective, optical, inductive, capacitive, ultrasonic, or other type of non-contact sensor that has the ability to measure the distance between the sensing unit 38 and the outer belt 26 to a sufficient degree of accuracy and generate an analog or digital signal indicative of that distance.

[0023] FIGS. 2A-2C are top views of the non-contact double feed detection system 10 shown in FIG. 1. The embodiments shown in FIGS. 2A-2C also include an item present detect ("IPD") sensing unit 60 (hereinafter referred to as "IPD") and a controller 64. The IPD 60 is positioned upstream of, or prior to the displacement sensor 34. The IPD 60 may include a variety of suitable sensors, including non-contact or mechanical displacement sensors that are capable of detecting the presence of an object. For example, in one embodiment, the IPD 60 includes a photocell that uses light to detect the presence of the mail 30. More specifically, in the embodiment shown in FIGS. 2A-2C, the IPD 60 includes a photocell that is positioned several inches upstream of the displacement sensing unit 38 that generates a signal as the mail 30 passes. In some embodiments, the signal generated by the IPD 60 is linked to the displacement sensing unit 38, and causes the displacement sensing unit 38 to toggle on and off according to the position of the mail 30. For example, as the leading edge of the mail 30 passes by the IPD 60, the IPD 60 generates a signal that is used to “trigger” or turn on the displacement sensing unit 38. The displacement sensing unit 38 then begins to measure the distance between the sensing unit 38 and the outer belt 26. In some embodiments, the signal that is generated by the IPD 60 is first received by the controller 64, and the controller 64 uses that signal to trigger the displacement sensing unit 38 via the power/communication cable 42. In other embodiments, the IPD 60 and the displacement sensing unit 38 may interact in a different manner (e.g., a direct connection between the IPD 60 and the sensing unit 38).

[0024] As described above, the controller 64 is electronically linked to both the displacement sensing unit 38 and the IPD 60. In some embodiments, the controller 64 is a conventional personal computer ("PC") that includes a data acquisition card 68 (e.g., a DAQ NI DAQ6013 PCI card). In other embodiments a different type of controller 64 may be implemented. For example, a programmable logic controller ("PLC") or other controller unit capable of receiving input signals and generating output signals may be employed. As described in greater detail below, the controller 64 communicates with both the IPD 60 and the displacement sensing unit 38 to generate an appropriate output 72, if the output 72 is required. The output 72 can include, for example, an audible and/or visual alert (e.g., a beeping sound, a flashing light, etc.). Alternatively, or additionally, the output 72 may affect the mail sorting equipment downstream of the displacement sensor 34, for example, by removing or culling out double-fed mail.

[0025] Referring now to FIG. 2A, the mail 30 is shown prior to, or upstream of the displacement sensing unit 38. As previously described, the inner belt 22 and the outer belt 26 of the mail sorting machine 14 are relatively flexible such that they conform to the shape of the mail 30, which creates a protrusion (e.g., a protrusion relative to the portion of the inner belt 22 and the outer belt 26 that is not holding the mail 30) that can be detected by the displacement sensing unit 38. The leading edge of a protrusion (and the corresponding piece of mail 30) is detected by the IPD 60, which transmits a signal to the controller 64 indicating that the mail 30 is present. The controller 64 receives this signal and triggers the displacement sensing unit 38. Additionally, the controller 64 begins to sample the signals generated by the displacement sensing unit 38 via the data acquisition card 68. For example, in some embodiments, the data acquisition card 68 receives the analog signal from the displacement sensing unit 38 such that approximately 200 samples can be gathered per piece of mail 30. The data acquisition card 68 then converts the analog signal to a digital signal and conditions the digital signal so that the controller 64 can create a thickness profile of the mail piece 30. The thickness profile is related to the thickness of the protrusion (and corresponding mail 30) along the length of the protrusion (and corresponding mail 30).

[0026] FIG. 2B shows mail 30 positioned near the displacement sensing unit 38. As described above, the displacement sensing unit 38 measures the deflection distance of the outer belt 26, which is used by the controller 64 and the data acquisition card 68 to generate a thickness profile. In the embodiment shown in FIG. 2B, as the mail 30 passes in front
of the displacement sensing unit 38 the controller 64 generates a thickness profile that corresponds to a single piece of mail. For example, the thickness profile that is generated in FIG. 2B has a single increase or step, a continuous and relatively constant raised portion, and a single step down. As described with respect to FIGS. 3-5, the thickness profile can be used to generate the output 72, if the output 72 is required. For example, if the thickness profile corresponds to a single piece of mail (i.e., no double feed condition is detected), the controller 64 may not generate the output 72. Alternatively, the controller 64 may generate an audible and/or visual output 72 indicating that the thickness profile corresponds to a single piece of mail 30 (e.g., lighting a green light on a light tree).

[0027] FIG. 2C also shows mail 30 positioned near the displacement sensing unit 38. However, in the embodiment shown in FIG. 2C, a double feed condition exists. Specifically, two pieces of overlapping mail 30 are positioned near the displacement sensing unit 38. As the overlapping pieces of mail 30 pass in front of the displacement sensing unit 38, a thickness profile is generated that corresponds to a double feed condition. As described with respect to FIGS. 3-5, there are a variety of ways to identify a thickness profile that corresponds to a double feed condition. After identifying that a double feed condition has occurred, the controller 64 may initiate an audible and/or visual signal output 72 indicating that a double feed condition exists. Alternatively, or additionally, the controller 64 may remove the mail 30 that has been identified as being double-fed.

[0028] FIG. 3 illustrates an exemplary process 100 that detects a double feed condition. In some embodiments, the process 100 is executed by the controller 64 to generate the output 72. As such, while executing the process 100, the controller 64 may generate or return a double feed confidence factor, which can then be utilized to generate the output 72. For example, in one embodiment, the controller 64 generates a double feed confidence factor that is based on a three-point scale (e.g., zero is a low double feed confidence, indicating there is no double feed condition present; three is a high double feed confidence, indicating that a double feed condition is likely). In such an embodiment, the controller 64 may not initiate the output 72 if the double feed confidence factor is zero, but may initiate the output if the double feed confidence factor is three.

[0029] The process 100 begins by inputting a thickness profile for a new piece of mail (“TP”) (step 104). As previously described, a thickness profile is related to the thickness of the mail 30 along its length. Accordingly, the thickness profile is input after the displacement sensing unit 38 measures the thickness of the mail 30 along the length of the mail 30 (see FIGS. 2A-2C). A maximum expected envelope length value (“MaxL”) and a minimum expected envelope length value (“MinL”) are also input during step 104. The process 100 continues by verifying that the length of the thickness profile of the new piece of mail (TP) is greater than the MinL value (step 108). If the length of the TP is not greater than the MinL value, the process 100 returns a double feed confidence of zero (e.g., if the length is less than the minimum length, a double condition cannot exist) (step 112). If, however, the length of the thickness profile is greater than the MinL value, the next step in the process 100 is to verify that there are at least three unique thickness points along the length of the TP (step 116). Verifying that there are at least three unique thickness points along the length of the TP confirms that there are at least two pieces of mail that are overlaid, with the thickest profile being the overlaid portion. If there are not at least three unique thickness points, the process 100 returns a double feed confidence of zero (step 120), indicating that a double feed condition has not occurred.

[0030] If there are at least three unique thickness points along the length of the TP, the next step in the process 100 is to build an array of difference values or “deltas” along the length of the TP (step 124). As shown in FIG. 6, for example, for two overlapping pieces of mail there may be a first delta or thickness step (D1) at the beginning of the overlapping portion, and a second delta or thickness step (D2) at the end of the overlapping portion. After the array of deltas is generated, the next step in the process 100 is to verify that there is a delta that matches the inverse of another delta (step 128). As shown in FIG. 6, for example, the delta (D1) and the delta (D2) are inverses or mirror images of one another. If there is not a delta that is an inverse of another delta (e.g., a “delta pair”), the process 100 returns a double feed confidence factor of one (step 132). The double feed confidence factor of one is returned because, while there were three unique thickness points identified in step 116, the delta values corresponding to those unique thickness points are not expected (i.e., a delta pair is not recognized), indicating inconsistent measurements. In some embodiments, a double feed confidence factor of one may be a signal of inaccurate measurements or faulty equipment.

[0031] If there is at least one valid delta pair, the process 100 continues by relating the delta values and the physical dimensions of the overlapping mail pieces (step 136). As shown in FIG. 6, for example, the beginning of mail piece 405 begins at delta (D1), while the end of mail piece 400 ends at delta (D2). Correspondingly, the beginning of the overlapping portion of mail begins at delta (D1), while the end of the overlapping portion of mail ends at delta (D2). Using the related delta and mail dimension data, the process 100 continues by calculating the dimensions of each mail piece (step 140). For example, the dimensions of the mail piece 400 can be calculated by subtracting the delta (D2) from the length of the TP (i.e., MailPieceOneLength=Length(TP)−D2). Additionally, the dimensions of the mail piece 405 can be calculated by subtracting the delta (D1) from the length of the TP (i.e., MailPieceTwoLength=Length(TP)−D1). After the dimensions of each piece have been calculated, the process 100 continues by verifying that the lengths of the mail pieces 400 and 405 are greater than the minimum mail piece size (MinL) (step 144), which may aid in verifying that the length values are accurate and a valid double feed condition has been identified. If either of the mail pieces is shorter than the minimum, the process 100 returns a double feed confidence factor of one (step 148). The double feed factor of one corresponds to a situation in which three unique thickness points were identified (step 116), but one or both of the first and second mail pieces is shorter than the minimum value MinL, which may indicate erroneous, invalid, and/or inconsistent measurements. When the process 100 returns a double feed confidence factor of one, the mail 30 may be culled out. Alternatively, the mail 30 may be rerouted through the mail sorting machine, or an audible or visual signal may also be used to indicate that erroneous, invalid, or inconsistent measurements have been identified. However, if each of the mail pieces is longer than the minimum
mail piece size (MinL), the process 100 returns a double feed confidence factor of two.

[0032] FIG. 4 illustrates another exemplary process 200 that can be used to identify a double feed condition. The process 200 may be most efficiently implemented if the mail stream is relatively uniform in size and shape. For example, the process 200 may be the most efficient at detecting a double feed condition if the mail 30 in the mail stream is, for example, a bulk mailing or other type of mass mailing (e.g., a large group of flyers, credit card offerings, insurance offerings, etc.). As described in greater detail below, the process 200 generally includes steps which compare a thickness profile from the mail 30 to a “historical” or previously stored thickness profile.

[0033] The process 200 begins by inputting a thickness profile for a new piece of mail (step 204). As previously described, the thickness profile for a new piece of mail can be created from the data provided by the displacement sensing unit 38. After a thickness profile has been created and input, the process 200 continues by checking if there is a “historical” thickness profile (step 208). A historical thickness profile is a thickness profile that has already been created and stored in the controller 64 (see FIGS. 2A-2C), and that corresponds to a previously sorted size and type of mail piece 30. The historical thickness profile can then be utilized as a standard or expected thickness profile for that size and type of mail 30 in the future. As a result, if the same size and type of mail is repeatedly run, the controller 64 has a standard thickness profile for that size and type of mail, as described in greater detail below.

[0034] If a historical thickness profile has not yet been created, the thickness profile of the new mail type is temporarily stored so that a new historical profile can be created (step 212). After a certain number of matching thickness profiles is temporarily stored, a new historical profile is created (also step 212). For example, a new historical profile may be created after five new and matching thickness profiles are consecutively stored. The number of matching thickness profiles that are needed to create a new historical thickness profile is a configurable value, and is generally large enough to provide confidence that the historical thickness profile represents the thickness profile of the current mail stream. After the new historical profile is created, or is in the process of being created (step 212), the process 200 returns a double feed confidence factor of zero (step 216). If a double feed condition interrupts the creation of a new historical thickness profile (e.g., overlapping mail passes by the displacement sensing unit 38 after only three matching thickness profiles), the mail pieces with the non-matching thickness profile may be culled out, and the process 200 may start over.

[0035] If a historical thickness profile has already been created (and confirmed in step 208), the process 200 continues by comparing the new thickness profile to the historical profile (step 220). If the new thickness profile matches the dimensions of the historical thickness profile, the process 200 assumes that a double feed condition has not occurred and returns a double feed confidence factor of zero (step 224). However, if the new thickness profile does not match the historical thickness profile, the next step in the process 200 is to generate an expected double feed thickness profile (step 228). As described in greater detail with respect to FIG. 5, generating an expected double feed thickness profile may include, for example, verifying that the total length of the new thickness profile is not greater than two times the length of the historical thickness profile, and calculating the offset between the two overlapping pieces of mail 30. After generating the expected double feed thickness profile (see FIG. 5) (step 228), the process 200 continues by checking if the expected double feed thickness profile matches the new thickness profile (step 232). If the expected double feed thickness profile and the new thickness profile match, a double feed confidence of three is returned (step 236). Returning a double feed confidence of three may lead to an audible or visual indication as well as the removal of the double feed from the mail stream.

[0036] However, if the generated double feed thickness profile does not match the new thickness profile, the historical thickness profile used to create the double feed thickness profile in step 228 is invalid (step 240). The process 200 continues by temporarily storing the new thickness profile so that a new historical thickness profile can be created as described above with respect to step 212. In other embodiments, the process 200 may have more or fewer steps than those shown in FIG. 4. For example, in an alternative embodiment, the process 200 may be abbreviated, such that expected double feed profile 228 is not calculated. Rather, if the new thickness profile does not match the historical thickness profile, the process 200 returns a double feed confidence factor of three. Other variations of the process 200 are also possible.

[0037] FIG. 5 illustrates an exemplary process 300 that can be used to generate a double feed thickness profile. The process 300 assumes that a historical thickness profile has been created, for example, using the process 200 shown in FIG. 4. The process 300 then creates a double feed thickness profile based on the current historical thickness profile and a length constant (L). The first step in the process 300 is to input the length of the “new” double feed thickness profile to generate a length constant (L) (step 304). As applied to the double feed detection process 200 described in FIG. 4, the length of the new double feed profile is analogous to the “new” thickness profile that is used in step 220.

[0038] The process 300 continues by verifying that the length (L) is a viable value (step 308). For example, the length (L) of the double feed profile must be greater than equal to the historical profile length (“HPL”) (i.e., the double feed cannot be shorter than a single piece of mail). Additionally, the length (L) of the double feed must also be smaller than two times the HPL (i.e., the double feed cannot be longer than two pieces of mail). If either of the conditions set forth in step 308 is not true, the process 300 ends (step 312) and returns an empty or null double thickness profile (i.e., the length (L) is invalid and a double feed thickness profile cannot be generated). However, if the length (L) is greater than or equal to the HPL, and the length (L) is less than two times the HPL, the process 300 continues by calculating the offset between the pieces of mail 30 (step 316). The offset is approximately equivalent to the amount or length of one piece of mail that extends beyond the other piece of mail (e.g., Offset-length (L)-HPL). If the overlapping mail pieces are not stacked directly on top of one another. For example, as shown in FIG. 7A, the leading edge of the first piece of mail 500 begins at zero. Accordingly, the leading edge of the second piece of mail 505 begins at the offset mark.

[0039] The process 300 continues by generating an “add-on” thickness profile (step 320). The add-on thickness profile is of length (L), and has a value of zero between the zero mark and the offset value, as shown in FIG. 7B. As also shown in FIG. 7B, the add-on thickness profile has a value
that is equal to the historical thickness profile from the offset value to the length (L). Combining the add-on thickness profile and the historical thickness profile yields the expected double feed profile (step 324). After the add-on and historical thickness profiles have been combined, the process 300 ends by returning the generated double feed thickness profile (step 328). In some embodiments, the double feed thickness profile is utilized by another process, for example, the process 200 shown in FIG. 4.

[0040] In some embodiments, the controller 64 can switch from one process to another and/or complete multiple processes, such as those described with respect to FIGS. 3-5, concurrently. For example, in one embodiment, the controller 64 begins by completing both the processes 100 and 200 concurrently. In such an embodiment, the process 100 is utilized to detect a double condition, while the process 200 generates a historical thickness profile (see step 212 of the process 200). Then, after a historical thickness profile is generated, the controller 64 utilizes the process 200 to detect a doubles condition. Other variations and process combinations are also possible.

[0041] Various embodiments of the invention are set forth in the following claims.

What is claimed is:

1. A non-contact sensing system for detecting a double feed condition of mail pieces, the non-contact sensing system comprising:
   a. a mail sorting machine having at least one conveyor
      configured to move the mail;
   b. a non-contact sensor positioned near the conveyor and
      configured to generate a signal indicative of a thickness
      of the mail being moved by the at least one conveyor;
   c. a controller configured to receive the signal from the
      non-contact sensor and generate an output signal
      indicative of a double feed condition.

2. The non-contact sensing system of claim 1, wherein the
   non-contact sensor is an optical sensor.

3. The non-contact sensing system of claim 1, wherein the
   non-contact sensor is a laser sensor.

4. The non-contact sensing system of claim 1, wherein the
   non-contact sensor is a reflective sensor.

5. The non-contact sensing system of claim 1, further
   comprising a second sensor configured to generate a second
   signal indicative of a leading edge of a mail piece.

6. The non-contact sensing system of claim 5, wherein the
   controller is configured to receive the second signal from
   the second sensor and initialize the non-contact sensor in
   response to the receipt of the second signal.

7. The non-contact sensing system of claim 1, wherein the
   controller is configured to generate a thickness profile, and
   the output signal is at least partially based on the thickness
   profile.

8. The non-contact sensing system of claim 7, wherein the
   thickness profile includes at least one thickness delta value,
   the thickness delta value corresponding to a change in
   thickness.

9. The non-contact sensing system of claim 7, wherein the
   thickness profile includes an add-on value, the add-on value
   based at least partially on an expected mail overlapping
   amount.

10. A method of calculating the likelihood of a double feed condition of mail, the method comprising:

   generating a thickness profile for the mail;
   comparing the thickness profile of the mail to a historical
   thickness profile; the historical thickness profile at least
   partially based on a previously generated thickness
   profile; and
calculating a confidence value associated with the likelihood of a double feed condition, the confidence value at least partially based on the comparison of the thickness profile to the historical thickness profile.

11. The method of claim 10, further comprising temporarily recording the thickness profile.

12. The method of claim 11, further comprising creating the historical thickness profile after comparing and matching a number of recorded thickness profiles.

13. The method of claim 10, further comprising generating an expected double feed profile, the expected double feed profile based at least partially on a comparison between the length of the thickness profile and the length of the historical thickness profile.

14. The method of claim 13, wherein generating the expected double feed profile comprises

   measuring the thickness and length of potentially overlapping pieces of mail with a non-contact sensor;
   generating a historical length based at least partially on a previously measured lengths of mail;
calculating an offset value between the potentially overlapping pieces of mail, the offset value based at least partially on the historical length;
   and
   generating a thickness profile of the potentially overlapping pieces of mail based at least partially on the offset value.

15. The method of claim 13, further comprising generating the confidence value based at least partially on the comparison of the thickness profile and the expected double feed thickness profile.

16. A method of calculating the likelihood of a double feed condition of mail, the method comprising:

   identifying a first distinct thickness and a second distinct thickness in the generated thickness profile of the mail,
   wherein a first transition between the first distinct thickness and the second distinct thickness is assigned a first position value;

   and
   identifying a double feed condition based at least partially in response to the detection of a second position value at a second transition between the first thickness and the second thickness.

17. The method of claim 16, further comprising relating the first position value and the second position value to a first piece of mail and a second piece of mail.

18. The method of claim 17, further comprising calculating the length of the first piece of mail and the length of the second piece of mail based at least partially on the first position value and the second position value.

19. The method of claim 18, further comprising verifying the length of the first piece of mail and the length of the second piece of mail are greater than a minimum length.

20. The method of claim 18, further comprising identifying a double feed condition based on the calculated length of the first piece of mail and the calculated length of the second piece of mail.