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WIRELESS TAG COMMUNICATION APPARATUS

Abstract

Provided is a wireless tag communication apparatus that detects a target wireless tag with high accuracy and reads information. A wireless tag communication apparatus according to an embodiment includes at least one antenna, a reading apparatus, and a drive apparatus. The antenna is disposed below a table where an article attached with a wireless tag is placed. The reading apparatus communicates with the wireless tag via the antenna, detects the wireless tag within a placement range on the table where the article is placed, and reads information from the wireless tag within the placement range. The drive apparatus moves the antenna inside the placement range.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2024-023750, filed on Feb. 20, 2024, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to a wireless tag communication apparatus and a wireless tag communication method.

BACKGROUND

[0003] In recent years, in order to perform a payment process, wireless tags are increasingly used instead of barcodes that are used conventionally.

[0004] In such a system, a wireless tag is attached to an article, the wireless tag is detected by a wireless tag communication apparatus, and information is read from the wireless tag. When exposed to electromagnetic wave emission, the wireless tag transmits an electromagnetic wave in response to the emission. The wireless tag communication apparatus emits an electromagnetic wave from an antenna and receives the electromagnetic wave transmitted from the wireless tag in response to the electromagnetic wave by the antenna, thereby detecting the wireless tag and reading information from the wireless tag.

Description

DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a block diagram of an example of a configuration of a wireless tag communication apparatus according to an embodiment.

[0006] FIG. **2** is a block diagram showing an example of a configuration of a reading apparatus shown in FIG. **1**.

[0007] FIG. **3** is a side view schematically showing an example of a configuration of a wireless tag communication apparatus according to a first embodiment.

[0008] FIG. **4** is a plan view schematically showing the example of the configuration of the wireless tag communication apparatus.

[0009] FIG. **5** is a flowchart showing a flow of an example of an operation of the wireless tag communication apparatus.

[0010] FIG. **6** is a side view schematically showing an example of a configuration of a wireless tag communication apparatus according to a second embodiment.

[0011] FIG. **7** is a plan view schematically showing the example of the configuration of the wireless tag communication apparatus.

[0012] FIG. **8** is a side view schematically showing an example of a configuration of a wireless tag communication apparatus according to a third embodiment.

[0013] FIG. **9** is a plan view schematically showing the example of the configuration of the wireless tag communication apparatus.

DETAILED DESCRIPTION

[0014] A wireless tag communication apparatus may also detect a non-target wireless tag located around a target wireless tag. Therefore, it is desirable that the wireless tag communication apparatus detects the target wireless tag with high accuracy and selectively reads information of the target wireless tag.

[0015] A problem to be solved by the disclosure is to provide a wireless tag communication apparatus that detects a target wireless tag with high accuracy and reads information.

[0016] A wireless tag communication apparatus according to an embodiment includes at least one antenna, a reading apparatus, and a drive apparatus. The antenna is disposed below a table where an article attached with a wireless tag is placed. The reading apparatus communicates with the wireless tag via the antenna, detects the wireless tag within a placement range on the table where the article is placed, and reads information from the wireless tag within the placement range. The drive apparatus moves the antenna inside the placement range.

[0017] Hereinafter, embodiments will be described with reference to the drawings. In the drawings referred to in the description of the embodiments, a scale of each part may be appropriately changed. In addition, each drawing may show an abbreviated configuration for a purpose of description.

Wireless Tag Communication Apparatus

[0018] First, a wireless tag communication apparatus **10** according to an embodiment will be described with reference to FIG. **1**. FIG. **1** is a block diagram of an example of a configuration of the wireless tag communication apparatus **10** according to the embodiment.

[0019] The wireless tag communication apparatus **10** determines whether a wireless tag **720** attached to an article **710** such as a commodity is within a predetermined range, and when the wireless tag **720** is within the predetermined range, reads information from the wireless tag **720** and processes the read information.

[0020] FIG. **1** shows one article **710** and one wireless tag **720** for convenience, but this is not intended to indicate the number of the articles **710** and the wireless tags **720**. The number of the articles **710** and the wireless tags **720** may be one or plural, and in general, is often plural. One wireless tag **720** is attached to one article **710**.

[0021] The wireless tag communication apparatus **10** includes a reading apparatus **100**, a drive apparatus **200**, an antenna **300**, a terminal **400**, a sensor **500**, and a notification apparatus **600**.

[0022] The reading apparatus **100** controls the drive apparatus **200** and the antenna **300** to read the information from the wireless tag **720**. A configuration example of the reading apparatus **100** will be described later.

[0023] The drive apparatus **200** is an apparatus that moves the antenna **300**. A configuration example of the drive apparatus **200** will be described later.

[0024] The antenna **300** is a device for communicating with the wireless tag **720**. The antenna **300** emits an electromagnetic wave. The antenna **300** receives an electromagnetic wave transmitted from the wireless tag **720** in response to the electromagnetic wave emission. The antenna **300** converts the radio wave received from the wireless tag **720** into a high-frequency signal and outputs the high-frequency signal to the reading apparatus **100**.

[0025] The terminal **400** is an apparatus that processes the information read from the wireless tag **720** by the reading apparatus **100**. The terminal **400** is a personal computer (PC) or the like, and is not limited thereto as long as the terminal **400** is an apparatus that processes information.

[0026] The sensor **500** is a device for acquiring position information of the wireless tag **720**. For example, the sensor **500** may be a camera. For example, the reading apparatus **100** may be configured to analyze an image captured by the camera to acquire the position information of the wireless tag **720**. Alternatively, the camera itself may be capable of acquiring the position information of the wireless tag **720**. The sensor **500** may be any device other than the camera as long as the sensor **500** can acquire the position information of the wireless tag **720**.

[0027] The notification apparatus **600** is a device that performs information notification. The notification apparatus **600** may be a device that includes a speaker and performs information notification by an audio output. The notification apparatus **600** may be a device that includes a display and performs information notification by an image display. Of course, the notification apparatus **600** may be a device that performs information notification by an audio output and an image display.

[0028] The wireless tag **720** is typically a radio frequency identification (RFID) tag. The wireless

tag **720** may be another wireless tag. The wireless tag **720** is a passive type wireless tag that operates using a predetermined radio wave transmitted from the antenna **300** as an energy source. The wireless tag **720** transmits a signal including the information stored in the wireless tag **720** by performing backscatter modulation on an unmodulated signal. For example, the information stored in the wireless tag **720** includes identification information that can be uniquely identified. For example, the information stored in the wireless tag **720** includes information on the article **710** to which the wireless tag **720** is attached.

Reading Apparatus

[0029] Hereinafter, the reading apparatus **100** will be described with reference to FIG. **2**. FIG. **2** is a block diagram of an example of a configuration of the reading apparatus **100**.

[0030] The reading apparatus **100** includes a processor **101**, a read-only memory (ROM) **102**, a random-access memory (RAM) **103**, a first connection interface **104**, a second connection interface **105**, a high-frequency front-end unit **108**, a digital amplitude modulation unit **109**, a digital-to-analog (DA) conversion unit **120**, an analog-to-digital (AD) conversion unit **111**, a demodulation unit **112**, and a memory device **113**. The units provided in the reading apparatus **100** can communicate with each other via a bus **114**.

[0031] The processor **101** corresponds to a central part of a computer that performs processing such as calculation and control necessary for an operation of the reading apparatus **100**. The processor **101** loads various programs stored in the ROM **102**, the memory device **113**, or the like into the RAM **103**. The processor **101** implements various functions for performing an operation necessary for the operation of the reading apparatus **100** by executing the programs loaded in the RAM **103**.

[0032] The processor **101** is, for example, a central processing unit (CPU), a micro processing unit (MPU), a system-on-a-chip (SoC), a digital signal processor (DSP), a graphics processing unit (GPU), an application-specific integrated circuit (ASIC), a programmable logic device (PLD), or a field-programmable gate array (FPGA). The processor **101** may be a combination of a plurality of these described above.

[0033] The ROM **102** corresponds to a main memory apparatus of the computer including the processor **101** as a center. The ROM **102** is a non-volatile memory used exclusively for reading data. The ROM **102** stores a program for causing the processor **101** to implement each function. The ROM **102** stores data or various setting values used when the processor **101** executes various types of processing.

[0034] The RAM **103** corresponds to a main memory apparatus of the computer including the processor **101** as the center. The RAM **103** is a memory used for reading and writing data. The RAM **103** is a work area for storing data used temporarily when the processor **101** executes various types of processing.

[0035] The first connection interface **104** is an interface for the reading apparatus **100** to communicate with the drive apparatus **200**.

[0036] The second connection interface **105** is an interface for the reading apparatus **100** to communicate with the terminal **400**.

[0037] A third connection interface is an interface for the reading apparatus **100** to communicate with the sensor **500**.

[0038] A fourth connection interface is an interface for the reading apparatus **100** to communicate with the notification apparatus **600**.

[0039] The high-frequency front-end unit **108** outputs a high-frequency signal to the antenna **300**. The high-frequency front-end unit **108** receives a high-frequency signal from the antenna **300**.

[0040] The digital amplitude modulation unit **109** adds information to be transmitted to the wireless tag **720** to a carrier wave to be transmitted to the wireless tag **720**.

[0041] The DA conversion unit **120** converts a digital signal modulated by the digital amplitude modulation unit **109** into an analog signal. The DA conversion unit **120** outputs a high-frequency signal to the antenna **300** via the high-frequency front-end unit **108**.

[0042] The AD conversion unit **111** converts the high-frequency signal received via the high-frequency front-end unit **108** from the antenna **300** into a digital signal.
[0043] The demodulation unit **112** extracts various types of information from the radio wave received from the wireless tag **720**. For example, the demodulation unit **112** extracts a unique identification code stored in the wireless tag **720** from the digital signal converted by the AD conversion unit **111**. When the radio wave of the wireless tag **720** is received by the antenna **300**, the demodulation unit **112** outputs, using a known technique, tag data of the wireless tag **720** in time series based on the digital signal converted by the AD conversion unit **111**. The tag data is time-series data based on the radio wave of the wireless tag **720** received by the antenna **300**. The tag data includes phase data. The phase data is data indicating a phase of the radio wave from the wireless tag **720**. The tag data includes received signal strength indicator (RSSI) data. The received signal strength indicator data is data indicating received signal strength of the radio wave from the wireless tag **720**. The tag data may include both the phase data and the received signal strength indicator data.
[0044] The memory device **113** is a non-volatile memory that stores data, programs, and the like. The memory device **113** includes a hard disk drive (HDD), a solid state drive (SSD), or the like, and is not limited thereto. The memory device **113** stores a program that causes the processor **101** to implement each function. The memory device **113** also stores data and the like used when the processor **101** executes various types of processing.
[0045] The processor **101** implements functions of the reading apparatus **100** by executing a program stored in the ROM **102** or the memory device **113**. The functions of the reading apparatus **100** include movement control of the antenna **300** by the drive apparatus **200**, communication control via the antenna **300**, position determination of the wireless tag **720**, information reading from the wireless tag **720**, information output to the terminal **400**, and the like.
First Embodiment
[0046] Hereinafter, a first embodiment of the wireless tag communication apparatus **10** will be described with reference to FIGS. **3** and **4**. FIG. **3** is a side view schematically showing an example of a configuration of the wireless tag communication apparatus **10** according to the first embodiment. FIG. **4** is a plan view schematically showing the example of the configuration of the wireless tag communication apparatus **10** according to the first embodiment. In FIGS. **3** and **4**, the article **710** is not shown, and only the wireless tag **720** is shown.
[0047] The wireless tag communication apparatus **10** according to the first embodiment includes an antenna **310**. The antenna **310** is movably held by the drive apparatus **200**. The drive apparatus **200** is provided under a table **740** where the article **710** (for example, a commodity) attached with the wireless tag **720** is placed. That is, the antenna **310** is movably disposed below the table **740**.
[0048] The table **740** is a horizontally held plate-like member. A placement range Ra is set on an upper surface of the table **740**. The placement range Ra is a range in which the wireless tag **720** is assumed in advance to be placed. For example, the placement range Ra is a range in which the article **710** attached with the wireless tag **720** or a basket **730** (for example, shopping basket) containing the article **710** is placed. For example, a contour of the placement range Ra is a circle. However, the contour of the placement range Ra is not limited thereto, and may be, for example, a polygon, rectangle, or an ellipse.
[0049] The drive apparatus **200** moves the antenna **310**. The drive apparatus **200** includes a stage **210** that holds the antenna **310** and a movement mechanism **220** that moves the stage **210**.
[0050] The stage **210** holds the antenna **310** such that a radiating surface of the antenna **310** faces the table **740**. The stage **210** includes a base plate **231** and a tilted holding portion **232**.
[0051] The base plate **231** is held horizontally by the movement mechanism **220**. For example, the base plate **231** is a rectangular plate-like member.
[0052] The tilted holding portion **232** stands upright on the base plate **231**. The tilted holding portion **232** tilts and holds the antenna **310** such that the radiating surface of the antenna **310** faces

upward of the placement range Ra.
[0053] The movement mechanism **220** is a rotation mechanism that rotates the stage **210** around a rotation center shaft **226**. The movement mechanism **220** includes a holding portion **221** and a motor **222**.
[0054] The holding portion **221** horizontally holds the stage **210**. That is, the holding portion **221** holds the stage **210** parallel to the table **740**. The holding portion **221** is fixed to a rotating shaft of the motor **222**.
[0055] The motor **222** rotates the holding portion **221** around the rotation center shaft **226**. The rotation center shaft **226** is perpendicular to a horizontal plane. That is, the rotation center shaft **226** is parallel to a vertical axis.
[0056] The movement mechanism **220** rotates the stage **210** around the rotation center shaft **226**. Accordingly, the antenna **310** moves along a circumference of a circle **225** or along a perimeter of a polygon.
[0057] The wireless tag communication apparatus **10** reads information from the wireless tag **720** attached to the article **710**. The wireless tag communication apparatus **10** regards the wireless tag **720** within the placement range Ra as a target to be read. However, the wireless tag communication apparatus **10** may also read information from a wireless tag **720** not to be read which is located outside the placement range Ra on the table **740**. In particular, when the wireless tag **720** not to be read is near the placement range, the wireless tag communication apparatus **10** is highly likely to erroneously read information from the wireless tag **720** not to be read.
[0058] In order to avoid such erroneous reading, the wireless tag communication apparatus **10** detects the wireless tag **720**, determines whether the detected wireless tag **720** is within the placement range Ra, regards only the wireless tag **720** within the placement range Ra as the target to be read, and reads information from only the wireless tag **720** that is the target to be read.
[0059] In one example, the position determination of whether the wireless tag **720** is within the placement range Ra is performed, based on a phase difference that is an amount of phase change, by moving the antenna **300** and measuring a phase of the wireless tag **720**. In another example, tag data of the wireless tag **720** is acquired at a plurality of positions by moving the antenna **300**, and a trained model generated by machine learning using the tag data as an input is used.
[0060] When performing measurement, the wireless tag communication apparatus **10** requests a user of the wireless tag communication apparatus **10** to place the wireless tag **720** within the placement range Ra. Here, the measurement includes detection of the wireless tag **720**, position determination of the wireless tag **720**, and reading of information from the wireless tag **720**.
[0061] Therefore, the wireless tag communication apparatus **10** determines whether the wireless tag **720** is within the placement range Ra based on information from the sensor **500**, and when the wireless tag **720** is at least partially out of the placement range Ra, the wireless tag communication apparatus **10** performs notification through the notification apparatus **600** to prompt the user to correct the position of the wireless tag **720**.
[0062] For example, when the article **710** attached with the wireless tag **720** or the basket **730** containing the article **710** extends beyond the placement range Ra, the wireless tag communication apparatus **10** performs notification to prompt the user to correct the position of the article **710** or the basket **730**. If the article **710** or the basket **730** is within the placement range Ra, it is guaranteed that the wireless tag **720** is within the placement range Ra.
[0063] The drive apparatus **200** two-dimensionally moves the antenna **310** inside the placement range Ra. Here, the two-dimensional movement of the antenna **310** means that, when two independent axes, for example, an X-axis and a Y-axis orthogonal to each other are set in a plane parallel to the upper surface of the table **740**, coordinates along the two axes of the antenna **310**, for example, an X coordinate and a Y coordinate both change regardless of the way of setting the axes.
[0064] In the present embodiment, the drive apparatus **200** moves the antenna **310** along a circumference of a circle **256** inside the placement range Ra. For example, the contour of the

placement range Ra is a circle that matches with a trajectory drawn by an outermost point **311** of the antenna **310** when the stage **210** is rotated around the rotation center shaft **226**.
[0065] In other words, the placement range Ra is set to a circle according to the trajectory of the antenna **310** such that the wireless tag **720** within the placement range Ra is preferentially detected with high accuracy. This is based on a concept that the wireless tag communication apparatus **10** detects the wireless tag **720** within the placement range Ra more easily than the wireless tag **720** outside the placement range Ra.
[0066] The placement range Ra is not necessarily limited to a range that matches the circle. The placement range Ra may be set to a range wider or narrower than the circle. The shape of the placement range Ra is not limited to a circle, and may be another shape. However, as the placement range Ra becomes wider than the circle, frequency of detecting the non-target wireless tag **720** increases, conversely, as the placement range Ra becomes narrower than the circle, frequency of missing the target wireless tag **720** for detection increases, and thus it is preferable that the placement range Ra is set in a range close to the circle.
[0067] Hereinafter, an example of an operation of the wireless tag communication apparatus **10** according to the present embodiment will be described with reference to FIG. **5**. FIG. **5** is a flowchart showing a flow of an example of the operation of the wireless tag communication apparatus **10** according to the present embodiment.
[0068] First, in ACT **11**, the reading apparatus **100** acquires information including the position information of the wireless tag **720** from the sensor **500**. For example, the sensor **500** is a camera, and the reading apparatus **100** acquires an image captured by the camera.
[0069] Then, in ACT **12**, the reading apparatus **100** calculates, by an image processing technique, a relative position between the wireless tag **720** and the placement range Ra based on the acquired captured image. For example, when the article **710** attached with the wireless tag **720** is placed alone on the table **740**, the reading apparatus **100** calculates a relative position between the article **710** and the placement range Ra. When the article **710** attached with the wireless tag **720** is contained in the basket **730** and placed on the table **740**, the reading apparatus **100** calculates a relative position between the basket **730** and the placement range Ra.
[0070] Position information of the placement range Ra necessary at that time may be acquired using an image processing technique by marking a circle or the like indicating the placement range Ra on the table **740** in advance, or information on the placement range Ra may be stored in advance.
[0071] Subsequently, in ACT **13**, the reading apparatus **100** determines whether the wireless tag **720** is within the placement range Ra. Therefore, the reading apparatus **100** determines whether the article **710** or the basket **730** is within the placement range Ra. If the article **710** or the basket **730** is within the placement range Ra, it is guaranteed that the wireless tag **720** is within the placement range Ra.
[0072] For example, whether the article **710** or the basket **730** is within the placement range Ra can be determined based on whether a contour of the article **710** or the basket **730** is located inside the placement range Ra without overlapping the contour of the placement range Ra.
[0073] When the article **710** or the basket **730** is not within the placement range Ra (NO in ACT **13**), in ACT **14**, the reading apparatus **100** performs notification for prompting correction of the position of the article **710** or the basket **730** by the notification apparatus **600**. Thereafter, the reading apparatus **100** returns to the processing in ACT**11** and performs the processing of ACT**11** to ACT**13** again.
[0074] When the article **710** or the basket **730** is within the placement range Ra (YES in ACT **13**), in ACT **15**, the reading apparatus **100** detects the wireless tag **720** and determines whether the wireless tag **720** is within the placement range Ra for each detected wireless tag **720**.
[0075] Then, in ACT **16**, the reading apparatus **100** reads information from the wireless tag **720** within the placement range Ra.

[0076] In the wireless tag communication apparatus **10** according to the present embodiment, the drive apparatus **200** two-dimensionally moves the antenna **310** inside the placement range Ra. For example, the drive apparatus **200** moves the antenna **310** along the circumference of the circle **225** inside the placement range Ra. Therefore, the electromagnetic wave emitted from the antenna **310** is emitted more to the inside of the placement range Ra and is emitted less to the outside of the placement range Ra. Therefore, the wireless tag communication apparatus **10** can detect the target wireless tag **720** within the placement range Ra with high accuracy and selectively read the information of the target wireless tag **720**.

[0077] The stage **210** holds the antenna **310** such that the radiating surface of the antenna **310** faces the table **740**. This also contributes to improvement in detection accuracy of the target wireless tag **720**.

Second Embodiment

[0078] Next, a second embodiment of the wireless tag communication apparatus **10** will be described with reference to FIGS. **6** and **7**. FIG. **6** is a side view schematically showing an example of a configuration of the wireless tag communication apparatus **10** according to the second embodiment. FIG. **7** is a plan view schematically showing the example of the configuration of the wireless tag communication apparatus **10** according to the second embodiment. FIGS. **6** and **7** correspond to FIGS. **3** and **4**, respectively. In FIGS. **6** and **7**, similarly to FIGS. **3** and **4**, the article **710** is not shown. The following description will focus on differences from the first embodiment.

[0079] The wireless tag communication apparatus **10** according to the second embodiment includes an antenna **320**. The antenna **320** is movably held by the drive apparatus **200** provided below the table **740**. A placement range Rb is set on the upper surface of the table **740**.

[0080] The drive apparatus **200** moves the antenna **320** along two axes, that is, an X-axis and a Y-axis that are parallel to the horizontal plane and perpendicular to each other. Therefore, the drive apparatus **200** includes a stage **230** that holds the antenna **320**, a movement mechanism **240** that moves the stage **230**, a stage **250** that holds the movement mechanism **240**, and a movement mechanism **240** that moves the stage **250**.

[0081] The stage **230** holds the antenna **320** such that a radiating surface of the antenna **320** faces the table **740**. For example, the stage **230** is a rectangular plate-like member.

[0082] The movement mechanism **240** is a linear motion mechanism that linearly moves the stage **230** in an X-axis direction. The movement mechanism **240** includes a guide rail **241** and a motor **245**. The guide rail **241** holds the stage **230** in a manner that allows linear movement in the X-axis direction. For example, the guide rail **241** includes a ball screw **242** therein. The ball screw **242** includes a rotatable screw shaft **243** and a nut **244** movable along the screw shaft **243** along with rotation of the screw shaft **243**. The nut **244** holds the stage **230**. The motor **245** rotates the screw shaft **243**. Rotational motion of the screw shaft **243** is converted into linear motion of the nut **244**.

[0083] Therefore, the stage **230** is linearly moved in the horizontal direction (X-axis direction) by rotating the motor **245**. For example, the stage **230** is linearly moved in a +X direction by rotating the motor **245** forward, and the stage **230** is linearly moved in a −X direction by rotating the motor **245** backward. That is, the stage **230** reciprocates in the X-axis direction by switching a rotation direction of a shaft of the motor **245**. Accordingly, the antenna **320** held by the stage **230** reciprocates in the X-axis direction.

[0084] The stage **250** holds the movement mechanism **240** horizontally. Specifically, the stage **250** holds the movement mechanism **240** such that a movement direction of the movement mechanism **240** is horizontal. For example, the stage **250** is a rectangular plate-like member.

[0085] A movement mechanism **260** is a linear motion mechanism that linearly moves the stage **250** in a Y-axis direction. The movement mechanism **260** has the same configuration as that of the movement mechanism **240**. That is, the movement mechanism **260** includes a guide rail **261** and a motor **265**. The guide rail **261** holds the stage **250** in a manner that allows linear movement in the Y-axis direction. For example, the guide rail **261** includes a ball screw **262** therein. The ball screw

262 includes a rotatable screw shaft **263** and a nut **264** movable along the screw shaft **263** along with rotation of the screw shaft **263**. The nut **264** holds the stage **250**. The motor **265** rotates the screw shaft **263**. Rotational motion of the screw shaft **263** is converted into linear motion of the nut **264**.

[0086] Therefore, the stage **250** is linearly moved in the horizontal direction (Y-axis direction) by rotating the motor **265**. For example, the stage **250** is linearly moved in a +Y direction by rotating the motor **265** forward, and the stage **250** is linearly moved in a −Y direction by rotating the motor **265** backward. That is, the stage **250** reciprocates in the Y-axis direction by switching a rotation direction of a shaft of the motor **265**. Accordingly, the movement mechanism **240** held by the stage **250** reciprocates in the Y-axis direction, and the antenna **320** held by the movement mechanism **240** reciprocates in the Y-axis direction.

[0087] The drive apparatus **200** two-dimensionally moves the antenna **310** inside the placement range Rb. In the present embodiment, the drive apparatus **200** moves the antenna **310** along the two axes inside the placement range Rb.

[0088] For example, as shown in FIG. **7**, the placement range Rb is set to a rectangle. The drive apparatus **200** moves the antenna **310** along the two axes, that is, the X-axis and the Y-axis in the placement range Rb, for example, such that the antenna **310** moves along a trajectory including a plurality of straight lines La, Lb, and Lc. The drive apparatus **200** moves the antenna **310** in a so-called zigzag manner.

[0089] Specifically, the drive apparatus **200** sequentially moves the antenna **310** from a position Pa to a position Pb, from the position Pb to a position Pc, and from the position Pc to a position Pd. The positions Pa, Pb, Pc, and Pd are positions where upper, lower, left, and right sides of the antenna **310** overlap upper, lower, left, and right sides of the placement range Rb, respectively. Directions of up, down, left, and right correspond to directions in FIG. **7**.

[0090] In other words, according to the same concept as in the first embodiment, the placement range Rb is set to a rectangle according to the trajectory of the antenna **310** such that the wireless tag **720** within the placement range Rb is preferentially detected with high accuracy. That is, the placement range Rb is set to a rectangle that matches a range in which the antenna **310** is movable by the drive apparatus **200**.

[0091] Although the placement range Rb does not necessarily match the range in which the antenna **310** is movable by the drive apparatus **200**, it is preferable to set the placement range Rb to a range close to the rectangle of the range in which the antenna **310** is movable by the drive apparatus **200** according to the same concept as in the first embodiment.

[0092] A trajectory between two positions among Pa, Pb, Pc, and Pd is not limited to a straight line, and may be a curve.

[0093] In the wireless tag communication apparatus **10** according to the present embodiment, the drive apparatus **200** two-dimensionally moves the antenna **310** inside the placement range Rb. For example, the drive apparatus **200** moves the antenna **310** in a zigzag manner inside the placement range Rb. Therefore, an electromagnetic wave emitted from the antenna **310** is emitted more to the inside of the placement range Rb and is emitted less to the outside of the placement range Rb. Therefore, the wireless tag communication apparatus **10** can detect the target wireless tag **720** within the placement range Rb with high accuracy and selectively read the information of the target wireless tag **720**.

Third Embodiment

[0094] Next, a third embodiment of the wireless tag communication apparatus **10** will be described with reference to FIGS. **8** and **9**. FIG. **8** is a side view schematically showing an example of a configuration of the wireless tag communication apparatus **10** according to the third embodiment. FIG. **9** is a plan view schematically showing the example of the configuration of the wireless tag communication apparatus **10** according to the third embodiment. FIGS. **8** and **9** correspond to FIGS. **3** and **4**, respectively. However, unlike FIG. **3**, an orientation of a paper surface in FIG. **8** is

perpendicular to the X-axis. In FIGS. **8** and **9**, similarly to FIGS. **3** and **4**, the article **710** is not shown. The following description will focus on differences from the first embodiment.

[0095] The wireless tag communication apparatus **10** according to the third embodiment includes two antennas **330** and **340**. The two antennas **330** and **340** are movably held by the drive apparatus **200** provided below the table **740**. A placement range Rc is set on the upper surface of the table **740**.

[0096] The drive apparatus **200** moves the two antennas **330** and **340** along the X-axis parallel to the horizontal plane. Therefore, the drive apparatus **200** includes a stage **270** that holds the two antennas **330** and **340**, and a movement mechanism **280** that moves the stage **270**.

[0097] The stage **270** holds the two antennas **330** and **340** such that radiating surfaces of the two antennas **330** and **340** face the table **740**.

[0098] The stage **270** holds the antennas **330** and **340** at a predetermined interval such that the radiating surfaces of the antennas **330** and **340** face the table **740**. The stage **270** includes a base plate **271** and two tilted holding portions **272** and **273**.

[0099] The base plate **271** is held horizontally by the movement mechanism **280**. For example, the base plate **271** is a rectangular plate-like member.

[0100] The two tilted holding portions **272** and **273** stand upright on the base plate **271**. The tilted holding portion **272** tilts and holds the antenna **330** such that the radiating surface of the antenna **330** faces upward of the placement range Rc. The tilted holding portion **273** tilts and holds the antenna **340** such that the radiating surface of the antenna **340** faces upward of the placement range Rc. The tilted holding portions **272** and **273** tilt and hold the antennas **330** and **340** such that the radiating surfaces of the antennas **330** and **340** face each other.

[0101] The movement mechanism **280** is a linear motion mechanism that linearly moves the stage **270** in the X-axis direction. The movement mechanism **280** includes a guide rail **281** and a motor **285**. The guide rail **281** holds the stage **270** in a manner that allows linear movement in the X-axis direction. For example, the guide rail **281** holds the stage **270** at an intermediate portion between the two antennas **330** and **340**. For example, the guide rail **281** includes a ball screw **282** therein. The ball screw **282** includes a rotatable screw shaft **283** and a nut **284** movable along the screw shaft **283** along with rotation of the screw shaft **283**. The nut **284** holds the stage **270**. The motor **285** rotates the screw shaft **283**. Rotational motion of the screw shaft **283** is converted into linear motion of the nut **284**.

[0102] Therefore, the stage **270** is linearly moved in the horizontal direction (X-axis direction) by rotating the motor **285**. For example, the stage **270** is linearly moved in the +X direction by rotating the motor **285** forward, and the stage **270** is linearly moved in the −X direction by rotating the motor **285** backward. That is, the stage **270** reciprocates in the X-axis direction by switching a rotation direction of a shaft of the motor **285**. Accordingly, the two antennas **330** and **340** held by the stage **270** reciprocate in the X-axis direction.

[0103] The drive apparatus **200** moves the two antennas **330** and **340** inside the placement range Rc. In the present embodiment, the drive apparatus **200** moves the two antennas **330** and **340** along the X-axis inside the placement range Rc.

[0104] For example, as shown in FIG. **9**, the placement range Rc is set to a rectangle. The drive apparatus **200** moves the two antennas **330** and **340** together along the X-axis within the placement range Rc.

[0105] Specifically, the drive apparatus **200** moves the antenna **330** from a position Pe to a position Pf and moves the antenna **340** from a position Pg to a position Ph. The positions Pe and Pf are positions where an upper side of the antenna **330** overlaps an upper side of the placement range Rc and left and right sides of the antenna **330** overlap left and right sides of the placement range Rc, respectively. The positions Pg and Ph are positions where a lower side of the antenna **340** overlaps a lower side of the placement range Rc and left and right sides of the antenna **340** overlap the left and right sides of the placement range Rc, respectively. Directions of up, down, left, and right

correspond to directions in FIG. **9**.
[0106] In other words, according to the same concept as in the first embodiment, the placement range Rc is set to a rectangle according to trajectories of the antennas **330** and **340** such that the wireless tag **720** within the placement range Rc is preferentially detected with high accuracy. That is, the placement range Rc is set to a rectangle surrounding a range in which the antennas **330** and **340** are movable by the drive apparatus **200**.
[0107] Although the placement range Rc does not necessarily match the rectangle surrounding the range in which the antennas **330** and **340** are movable by the drive apparatus **200**, it is preferable to set the placement range Rc to a range close to the rectangle surrounding the range in which the antennas **330** and **340** are movable by the drive apparatus **200** according to the same concept as in the first embodiment.
[0108] The wireless tag communication apparatus **10** according to the present embodiment includes the two antennas **330** and **340**, and the drive apparatus **200** moves the two antennas **330** and **340** together inside the placement range Rc. This provides the same effect as moving one antenna two-dimensionally inside the placement range Rc. That is, electromagnetic waves emitted from the two antennas **330** and **340** are emitted more to the inside of the placement range Rc and are emitted less to the outside of the placement range Rc. Therefore, the wireless tag communication apparatus **10** can detect the target wireless tag **720** within the placement range Rc with high accuracy and selectively read the information of the target wireless tag **720**.
[0109] While certain embodiments have been described, these embodiments have been presented by way of examples only, and are not intended to limit the scope of the disclosure. These novel embodiments can be implemented in various other forms, and various omissions, substitutions, and modifications can be made in a range not departing from the gist of the disclosure. The embodiments and the modifications thereof are included in the scope and the gist of the disclosure, and are included in the scope of the disclosure disclosed in the claims and equivalents thereof.

Claims

1. A wireless tag communication apparatus, comprising: at least one antenna disposed below a table where an article attached with a wireless tag is placed; a reading apparatus configured to communicate with the wireless tag via the antenna, detect the wireless tag within a placement range on the table where the article is placed, and read information from the wireless tag within the placement range; and a drive apparatus configured to move the antenna inside the placement range.
2. The wireless tag communication apparatus according to claim 1, further comprising: a sensor configured to acquire position information of the wireless tag; and a notification apparatus configured to perform information notification, wherein the reading apparatus determines a relative position between the placement range and the wireless tag, and causes the notification apparatus to perform notification of information for prompting correction of a position of the article when the wireless tag is at least partially out of the placement range.
3. The wireless tag communication apparatus according to claim 1, wherein the drive apparatus moves the antenna such that the antenna moves along a perimeter of a polygon or a circumference of a circle.
4. The wireless tag communication apparatus according to claim 1, wherein the drive apparatus moves the antenna along two axes such that the antenna moves along a trajectory including a plurality of straight lines.
5. The wireless tag communication apparatus according to claim 4, wherein the two axes are perpendicular with each other.
6. The wireless tag communication apparatus according to claim 4, wherein the two axes are parallel with each other.
7. The wireless tag communication apparatus according to claim 1, wherein the drive apparatus

includes a stage configured to hold the antenna in a tilted manner such that a radiating surface of the antenna faces upward of the placement range, and a movement mechanism configured to move the stage.

8. The wireless tag communication apparatus according to claim 2, wherein the sensor is a camera.

9. The wireless tag communication apparatus according to claim 1, wherein the reading apparatus is further configured not to detect the wireless tag that is outside of the placement range.

10. The wireless tag communication apparatus according to claim 1, wherein the drive apparatus moves the antenna in a two dimensional direction parallel with a placing surface of the table.

11. A wireless tag communication method, comprising: communicating with a wireless tag attached to an article placed on a table with an antenna disposed below the table; detecting the wireless tag within a placement range on the table where the article is placed; reading information from the wireless tag within the placement range; and moving the antenna inside the placement range using a drive apparatus.

12. The wireless tag communication method according to claim 11, further comprising: acquiring position information of the wireless tag; performing information notification with a notification apparatus; and determining a relative position between the placement range and the wireless tag, and causing the notification apparatus to perform notification of information for prompting correction of a position of the article when the wireless tag is at least partially out of the placement range.

13. The wireless tag communication method according to claim 11, further comprising: moving the antenna such that the antenna moves along a perimeter of a polygon or a circumference of a circle.

14. The wireless tag communication method according to claim 11, further comprising: moving the antenna along two axes such that the antenna moves along a trajectory including a plurality of straight lines.

15. The wireless tag communication method according to claim 14, wherein the two axes are perpendicular with each other.

16. The wireless tag communication method according to claim 14, wherein the two axes are parallel with each other.

17. The wireless tag communication method according to claim 11, further comprising: holding, using a stage, the antenna in a tilted manner such that a radiating surface of the antenna faces upward of the placement range; and moving the stage.

18. The wireless tag communication method according to claim 12, further comprising: using a camera to acquire the position information.

19. The wireless tag communication method according to claim 11, further comprising: not detecting the wireless tag that is outside of the placement range.

20. The wireless tag communication method according to claim 11, further comprising: moving the antenna in a two dimensional direction parallel with a placing surface of the table.