CLAIMS:

1. A volume measurement apparatus, comprising:

a point group conversion part that converts depth information related to a raw material yard from a depth sensor that shoots the raw material yard having a raw material heap into point group data related to the raw material yard;

a raw material heap detection part that detects a point group related to the raw material heap from the point group data related to the raw material yard, using repose angle information related to a repose angle of the raw material heap; and

a raw material heap volume calculation part that calculates a volume of the raw material heap non-occlusion part that can be shot from the depth sensor in the raw material heap based on the point group related to the raw material heap; estimates a volume of the raw material heap occlusion part that cannot be shot from the depth sensor in the raw material heap, using at least the point group related to the raw material heap; and calculates a volume of the raw material heap, which is a sum of the calculated volume of the raw material heap non-occlusion part and the estimated volume of the raw material heap occlusion part.

2. The volume measurement apparatus according to claim 1,

wherein when detecting a point group related to the raw material heap, the raw material heap detection part detects a point group where an angle formed by a plane on a slope of the raw material heap and a ground surface in the raw material yard satisfies the repose angle in the repose angle information, as the point group related to the raw material heap.

3. The volume measurement apparatus according to claim 1 or 2, further comprising a repose angle memory part that stores repose angle information for rainy weather and repose angle information for non-rainy weather,

wherein when detecting the point group related to the raw material heap, the raw material heap detection part confirms whether or not a rain sensor that detects a rainfall in the raw material yard detects

a rainfall; reads-out the repose angle information for rainy weather from the repose angle memory part when the rain sensor detects a rainfall; reads-out the repose angle information for non-rainy weather from the repose angle memory part when the rain sensor does not detect rainfall; and detects a point group related to the raw material heap from the point group data related to the raw material yard, using the read-out repose angle information for rainy weather or the read-out repose angle information for non-rainy weather.

4. The volume measurement apparatus according to claim 1 or 2,

wherein when detecting the point group related to the raw material heap, the raw material heap detection part measures repose angle information, using an image data from a camera, and detects a point group related to the raw material heap from the point group data related to the raw material yard, using the measured repose angle information.

5. The volume measurement apparatus according to any one of claims 1 to 4,

wherein the raw material heap detection part further confirms whether or not there is a point group related to an obstacle existing between the raw material heap and the depth sensor in the point group data related to the raw material yard; removes the point group related to the obstacle from the detected point group related to the raw material heap when there is the point group related to the obstacle; and interpolates a point group related to a deficient part in the point group related to the raw material heap, the deficient part being caused by removing the point group related to the obstacle; and

wherein in a case where the volume of the raw material heap non-occlusion part calculates, the raw material heap volume calculation part calculates a volume of the raw material heap non-occlusion part based on the point group related to the raw material heap in which the point group related to the deficient part is interpolated by the raw material heap detection part.

6. The volume measurement apparatus according to any one of

claims 1 to 5,

wherein in a case where the volume of the raw material heap non-occlusion part calculates, the raw material heap volume calculation part creates a convex hull configured of a plurality of tetrahedrons based on a point group related to the raw material heap; calculates a volume of the entire convex hull by calculating a total volume of each of the plurality of tetrahedrons; and defines the calculated volume of the entire convex hull as the volume of the raw material heap non-occlusion part.

7. The volume measurement apparatus according to any one of claims 1 to 6, further comprising a wall position memory part that stores wall position information related to a wall position in the raw material yard,

wherein when estimating the volume of the raw material heap occlusion part, the raw material heap volume calculation part confirms whether or not there is a wall in the raw material yard, using the point group related to the raw material heap; reads-out the wall position information from the wall position memory part when there is a wall; and estimates a volume of the raw material heap occlusion part, using the point group related to the raw material heap and the wall position information.

8. The volume measurement apparatus according to claim 7,

wherein when estimating the volume of the raw material heap occlusion part, the raw material heap volume calculation part cuts-out a part corresponding to a distance between an apex of the raw material heap and the wall from the point group related to the raw material heap; creates a convex hull configured of a plurality of tetrahedrons based on a point group related to the cut-out part; calculates a volume of the entire convex hull by calculating a total volume of each of the plurality of tetrahedrons; and defines the calculated volume of the entire convex hull as the volume of the raw material heap occlusion part.

9. A volume measurement system, comprising:

a depth sensor that shoots a raw material yard having a raw material heap; and

a volume measurement apparatus according to any one of claims 1 to 8.

10. A volume measurement method, comprising:

converting depth information related to a raw material yard from a depth sensor that shoots the raw material yard having a raw material heap into point group data related to the raw material yard;

detecting a point group related to the raw material heap from the point group data related to the raw material yard, using repose angle information related to a repose angle of the raw material heap;

calculating a volume of the raw material heap non-occlusion part that can be shot from the depth sensor in the raw material heap based on the point group related to the raw material heap;

estimating a volume of the raw material heap occlusion part that cannot be shot from the depth sensor in the raw material heap, using at least the point group related to the raw material heap; and

calculating a volume of the raw material heap, which is a sum of the calculated volume of the raw material heap non-occlusion part and the estimated volume of the raw material heap occlusion part.

11. A program causing hardware resources to execute processings comprising:

converting depth information related to a raw material yard from a depth sensor that shoots the raw material yard having a raw material heap into point group data related to the raw material yard;

detecting a point group related to the raw material heap from the point group data related to the raw material yard, using repose angle information related to a repose angle of the raw material heap;

calculating a volume of the raw material heap non-occlusion part that can be shot from the depth sensor in the raw material heap based on the point group related to the raw material heap;

estimating a volume of the raw material heap occlusion part that cannot be shot from the depth sensor in the raw material heap, using at least the point group related to the raw material heap; and

calculating a volume of the raw material heap, which is a sum of

the calculated volume of the raw material heap non-occlusion part and the estimated volume of the raw material heap occlusion part.