

GOLF BALL TRACKING SYSTEM**7.0 CLAIMS**

1. A ball tracking system comprising:
 - a display;
 - a sensor positioned to detect a plurality of observed ball flight paths, each in the
 - 5 plurality originating from a different ball strike at a different location; and
 - wherein the sensor is correlated to three-dimensional space;
 - a launch monitor positioned to detect one of the ball strikes, and measure the launch
 - parameters of that ball strike;
 - a processor connected to the display, sensor and launch monitor, wherein the
 - 10 processor is adapted to perform the following steps:
 - a. receive the launch parameters from the launch monitor;
 - b. calculate a predicted ball flight path based on the launch parameters;
 - c. receive image data from the sensor;
 - d. from the image data identify an observed ball flight path and a landing
 - 15 event for each of the plurality of observed ball flights paths;
 - e. determine a landing location for each identified landing event;
 - f. based on the predicted ball flight path determine a matching distance for
 - each of the plurality of landing locations;
 - g. select the matching distance that is closest to the predicted ball flight path;
 - 20 h. morph the predicted ball flight path with the observed ball flight path and
 - landing location associated with the closest distance; and
 - i. communicate to the display a video rendering based on the morphed ball
 - flight path.
- 25 2. The ball tracking system of claim 1, wherein the processor is adapted to perform the following additional steps:
 - j. morph the predicted ball flight path with the observed ball flight path and
 - landing location associated with the closest distance; and
 - k. communicate to the display a video rendering based on the morphed ball
 - 30 flight path.

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3. The ball tracking system of claim 1, wherein:

step (e) further includes determining the time of the landing event; and

the matching distance in step (f) includes a temporal and a spatial measure of distance.

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4. The ball tracking system of claim 3, wherein:

step (e) further includes determining an observed descent angle and observed impact speed prior to the landing event; and

the matching distance in step (f) is based on the observed descent angle and observed impact speed.

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5. The ball tracking system of claim 1, wherein the predicted ball flight path of step (b) includes t_p (time of landing) and $(x, y, z)_p$ (landing position) and the landing location for each identified landing events of step (e) includes t_0 (time of landing) and $(x, y, z)_0$ (landing position) and the matching distance is based on the following equation:

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$$D_1 = \frac{|t_p - t_0|}{\text{timeout}} \times K_t + \sqrt{(x_p - x_0)^2 + (y_p - y_0)^2 + (z_p - z_0)^2} \times K_p$$

where *timeout* is a preset time, K_t and K_p are time and position calibration constants, respectively.

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6. The ball tracking system of claim 5, wherein the calibration constants are automatically adjusted based on prior system accuracy.

7. The ball tracking system of claim 5, wherein the predicted ball flight path of step (b) includes s_p (impact speed) and A_p (descent angle) and the landing location for each identified landing event of step (e) includes s_0 (impact speed) and A_0 (descent angle), and the matching distance is further based on the following equation:

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$$D_2 = D_1 + |s_p - s_0| \times K_s + |A_p - A_0| \times K_a$$

where K_s and K_a are speed and angle calibration constants, respectively.

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8. The ball tracking system of claim 7, wherein D2 is performed on a subset of plurality of observed ball flight paths whose D1 values are within a refinement margin.
- 5 9. The ball tracking system of claim 8, wherein the refinement margin is based on the closest D1 value.
- 10 10. The ball tracking system of claim 7, wherein the calibration constants are automatically adjusted based on prior system accuracy.
- 10 11. The ball tracking system of claim 2, wherein step (g) includes:
- (g)(1) compare the closest matching distance to a confidence margin,
 - (g)(2) if the closest matching distance is within the confidence margin then continue to steps (h) and (i);
 - (g)(3) if the closest matching distance is not within the confidence margin
- 15 then skip steps (h) and (i), and communicate to the display a video rendering based on predicted ball flight path.
12. The ball tracking system of claim 2, wherein:
- steps (a), (b), (h) and (i) are performed by a simulator;
 - 20 steps (c), (d) and (e) are performed by a target processor; and
 - steps (f) and (g) are performed by a fusion processor.
13. The ball tracking system of claim 1, wherein step (d) includes:
- (d)(1) capturing image frames;
 - 25 (d)(2) performing background subtraction;
 - (d)(3) performing ball discovery;
 - (d)(4) performing ball chaining; and
 - (d)(5) performing event detection.
- 30 14. The ball tracking system of claim 2, wherein:

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step (i) is delayed for a time period after the launch monitor detects the ball strike; and

a beginning portion of the rendering is based on the predicted ball flight path and an ending portion of the rendering is based on the observed ball flight path and landing location associated with the closest distance.

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15. The ball tracking system of claim 14, wherein the beginning portion has a rendering perspective view and the ending portion has a second rendering perspective view that is different from the first.

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16. The ball tracking system of claim 15, further comprising a rendering transition from the first to the second rendering perspective view, and the transition is discrete.

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17. The ball tracking system of claim 15, further comprising a rendering transition from the first to the second rendering perspective view, and the transition is smooth.

18. The ball tracking system of claim 1, the system comprising:

an atmospheric sensor connected to the processor that measure environmental data;
wherein the predicted ball flight path is further based on the environmental data.

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19. The ball tracking system of claim 1, further comprising a plurality of sensors and a plurality of launch monitors.

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20. The ball tracking system of claim 19, wherein the each launch monitor of the plurality of launch monitors is located in a separate driving bay.

21. The ball tracking system of claim 1, wherein the launch monitor comprises a side-positioned launch monitor and an overhead launch monitor.

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22. The ball tracking system of claim 1, wherein the display comprises a portable device.

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23. The ball tracking system of claim 1, wherein the processor is adapted to perform the following additional step of assigning a point value to the ball flight path associated with the closest distance, wherein the point value is based on the landing location associated with the closest distance.

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24. A method for ball tracking for use with a display, a sensor positioned to detect a plurality of observed ball flight paths, each in the plurality originating from a different ball strike at a different location, and wherein the sensor is correlated to three-dimensional space, a launch monitor positioned to detect one of the ball strikes, and measure the launch parameters of that ball strike, the method comprising:

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- a. receive the launch parameters from the launch monitor;
- b. calculate a predicted ball flight path based on the launch parameters;
- c. receive image data from the sensor;
- d. from the image data identify an observed ball flight path and a landing event for each of the plurality of observed ball flights paths;
- e. determine a landing location for each identified landing event;
- f. based on the predicted ball flight path determine a matching distance for each of the plurality of landing locations; and
- g. select the matching distance that is closest to the predicted ball flight path;

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25. The method of claim 24 further comprising the steps of:

- h. morph the predicted ball flight path with the observed ball flight path and landing location associated with the closest distance; and
- i. communicate to the display a video rendering based on the morphed ball flight path

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26. The method of claim 24, further comprising the step of assigning a point value to the ball flight path associated with the closest distance, wherein the point value is based on the landing location associated with the closest distance.

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27. A data processing apparatus comprising a processor configured to perform the method of claim 24.

28. The data processing apparatus of claim 27 wherein the processor is further configured to perform the followings steps:

morph the predicted ball flight path with the observed ball flight path and landing location associated with the closest distance; and
communicate to the display a video rendering based on the morphed ball flight path.

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