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Position-based laser range finder

Abstract

Techniques are provided for implementing a system for determining the range to a target object. In implementations, a system for determining a range estimate to a target includes a rangefinder, a camera, a display and at least one processor. A processor may acquire an image from the camera, identify a target flagstick within the image acquired from the camera and modify pixels proximate to the identified target flagstick of the image to generate a modified image contrasting the target flagstick from objects in the background. The processor may calculate a range estimate to the target flagstick using the rangefinder and present, on the display, the modified image and a representation of the range estimate of the target flagstick.

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Background/Summary

BACKGROUND

(1) Optical laser rangefinders are often used by golfers to measure distance to a flagstick or other hole features. In most situations, the general location of the green is static, and thus may be contained in cartographic data, but the exact location of the hole on the green changes from day to day. Accurately measuring the distance to a flagstick in the hole can be difficult for a number of reasons, including the small cross-sectional area of the flagstick for targeting, a significant distance between a user and the hole, hand jitter of the user, or the obscuring effect of environmental objects such as trees.

SUMMARY

(2) Embodiments provide an optical rangefinder system that provides a user with an estimation of the position of a target. A first embodiment includes a system for determining a position of a target comprising a rangefinder, a communications module, a display, a memory unit storing a set of cartographic data, and one or more processors. The processor(s) are operable to obtain the geographic location of the system from the communications module, determine an approximate range envelope to the target, adjust an operating parameter of the system based on that range envelope, performing a rangefinding operation based on the adjusted operating parameter, and display the range estimate on the display. The rangefinder includes a transmitter operable to emit one or more pulses towards the target and a receiver operable to receive reflections of the pulses. The communications module may be a GPS receiver or may communicate with a GPS receiver housed in a mobile electronic device.

(3) For example, using a device comprising a GPS receiver, a heading sensor, and cartographic data corresponding to a hole, an embodiment uses the GPS sensed location and cartographic data to determine a maximum and minimum range to a target flagstick. The device may then perform a laser measurement of the distance to the flagstick, using the maximum and minimum ranges to filter out signals reflected from objects in the foreground or background.

(4) In a second embodiment, a system for determining a position of a target comprises a rangefinder, a communications module, a display, a memory unit storing a set of cartographic data, and one or more processors. The system may further include an orientation determining component, such as a compass heading sensor, which is operable to determine the orientation of the system. The one or more processors may cause the system to enter a mode of operation based on a user activation, the geographic location, and/or the sensed orientation of the device. One or more operating parameters of the system may be adjusted by the one or more processors based on the mode of operation and/or an approximate range to the target. The processor(s) are operable to calculate a range estimate of the target using the rangefinder based on the adjusted operating parameters and display the range estimate on the display. The modes of operation may correspond to a scanning, holding, aiming, or target seek function of the system.

(5) In a third embodiment, a system for determining a position of a target comprises a rangefinder, a communications module, an orientation determining component, a display, a memory unit storing a set of cartographic data, and one or more processors. The one or more processors may cause the system to enter a target seek mode based on the geographic location and the orientation of the system. One or more operating parameters of the system may be adjusted by the one or more

processors based on the target seek mode and/or an approximate range to the target. The processor(s) are operable to calculate a range estimate of the target using the rangefinder based on the adjusted operating parameters and display the range estimate on the display. The system may further comprise a camera, which the one or more processors may utilize to capture an image of the proximity of the target and search pixels in that image for information indicative of the target.

Description

BRIEF DESCRIPTION OF THE DRAWING FIGURES

(1) The figures described below depict various aspects of the system and methods disclosed herein. It should be understood that each figure depicts an embodiment of a particular aspect of the disclosed system and methods, and that each of the figures is intended to accord with a possible embodiment thereof. Further, whenever possible, the following description refers to the reference numerals included in the following figures, in which features depicted in multiple figures are designated with consistent reference numerals.

(2) FIG. **1** illustrates an exemplary golfing situation in which embodiments of the system may be used;

(3) FIG. **2** is a schematic illustration of an exemplary position and distance measurement system **200** in accordance with an embodiment of the disclosure;

(4) FIG. **3** is a perspective illustration of one embodiment of a targeting device;

(5) FIG. **4** is an illustration of a first method flow **400**, according to an embodiment;

(6) FIG. **5** is a first schematic illustration example of a user interface screens that may be displayed in conjunction with a position and distance measurement system, according to an embodiment;

(7) FIG. **6** is a second schematic illustration example of a user interface screens that may be displayed in conjunction with a position and distance measurement system, according to an embodiment;

(8) FIG. **7** is a third illustration example of a user interface screens that may be displayed in conjunction with a position and distance measurement system, according to an embodiment;

(9) FIG. **8** illustrates the reflectivity of common terrestrial materials likely to encountered around the golf course; and

(10) FIG. **9** illustrates a method flow **900**, according to an embodiment.

DETAILED DESCRIPTION

Overview

(11) The following text sets forth a detailed description of numerous different embodiments. However, it should be understood that the detailed description is to be construed as exemplary only and does not describe every possible embodiment since describing every possible embodiment would be impractical. In light of the teachings and disclosures herein, numerous alternative embodiments may be implemented.

(12) Embodiments are disclosed describing an optical-based rangefinding system for use in conjunction with cartographic data. As seen in FIG. **1**, the system may include one or more electronic targeting devices **202** operated by a user to determine the distance to and/or position of a target **106**, such as the flagstick of a golf hole. Embodiments may use stored information related to a proximity of the target, such as green **104**, to reduce the impact of signals from unintended targets, such as trees **110** and **112**. As used in this description, the term "flagstick" is intended to include both the flag and pole portions of the flag placed in a golf hole.

(13) Embodiments of systems disclosed may include one or more processors operable to calculate a range estimate of the target by performing a rangefinding operation with a rangefinder component having an optical transmitter and receiver. The optical transmitter is operable to transmit one or more pulses of a light beam towards a target. The rangefinding operation is based, at least in part,

on one or more operating parameters that are determined by the system based on the cartographic data **214** and the sensed geographic location of the system.

(14) The cartographic data **214** may include a map of the proximity of the system **200** and the target **106**. Cartographic data **214** may include cardinal directions, elevations, or any other navigation or orientation data. The cartographic data **214** may further include, in some embodiments, an approximate range envelope of the target. For example, when used for rangefinding of a target golf flagstick, the cartographic data **214** may include data indicating the position of the green, hazards, tees, or any other location of interest for a particular hole or golf course.

(15) The exact location of a hole on a green is variable from day to day, but it will usually be somewhere within the boundaries of the green. Thus, cartographic data **214** stored in memory **212** may include a range envelope for possible positions of the hole based on data indicating green locations and the sensed geographic position of the system. The range envelope may, for example, be defined by a maximum and minimum range from the geographic location of the system. Based on the range envelope, an operating parameter may be adjusted before, during, and/or after emitting one or more pulses from a transmitter portion of the rangefinder and subsequent reception of the reflections of the pulses by a receiver portion of the rangefinder to improve and/or speed an estimation of the distance to the target.

(16) The system may, in some embodiments, collect a plurality of range estimates of the range to the target and output a final range estimate to the user via a display when a threshold number of the range estimates agree on a particular range estimate. The threshold number that must agree may be set by any means, such as manually by a user, by a remote control of the system from a remote location, from data stored in memory, or by a process performed by one or more processors of the system.

(17) One or more modes may be entered by the system manually and/or automatically based on sensed values such as the geographic location of the system and/or a sensed orientation of the system to further adjust the one or more operating parameters. In some embodiments, modes of operation may account for a use of the system, a movement pattern, and/or may provide targeting assistance to a user of the system.

Hardware

(18) FIG. **2** is an illustration of a block diagram of an exemplary rangefinding system **200** in accordance with an embodiment of the disclosure.

(19) In some embodiments, targeting device **202** may act as a standalone electronic device and not require communications with external computing devices such as mobile device **250** or remote server **260**. In other embodiments, which are further discussed below, targeting device **202** may communicate with and/or work in conjunction with one or more of external computing devices **250** and/or **260**.

(20) Targeting device **202**, one or more mobile devices **250**, and/or one or more remote servers **260** may be configured to communicate with one another using any suitable number of communication networks and wired and/or wireless links (e.g., communication network **270**, wired and/or wireless links, etc.) in conjunction with any suitable number and type of communication protocols.

(21) In an embodiment, one or more of mobile devices **250** and/or remote servers **260** may include any suitable number and/or type of computing devices configured to communicate with and/or exchange data with targeting device **202**. For example, one or more of mobile devices **250** may be implemented as a handheld computing device (e.g., smartphone, tablet, laptop, netbook, notebook, pager, personal digital assistant (PDA), wearable computing device, smart glasses, a smart watch or a bracelet, etc.), or any other suitable type of computing device capable of wired and/or wireless communication, while one or more of remote servers **260** may be implemented as one or more cloud data services, web servers, databases, etc.

(22) In an embodiment, targeting device **202** may communicate with one or more of mobile devices

250 and/or remote servers **260** to send data to and/or to receive data from mobile devices **250** and/or remote servers **260**. For example, targeting device **202** may communicate with one or more mobile devices **250** to receive updated cartographic data **214**. To provide another example, targeting device **202** may communicate with one or more remote servers **260** to receive golf course data and/or to send data collected, measured, and/or generated by targeting device **202** to remote servers **260** (e.g., geographic position data, orientation data, etc., as further discussed below).

(23) Communication network **270** may include any suitable number of nodes, additional wired and/or wireless networks, etc., in various embodiments. For example, in an embodiment, communication network **270** may be implemented with any suitable number of base stations, landline connections, internet service provider (ISP) backbone connections, satellite links, public switched telephone network (PSTN) connections, local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs), any suitable combination of local and/or external network connections, etc. To provide further examples, communication network **270** may include wired telephone and/or cable hardware, satellite, cellular phone communication networks, etc. In various embodiments, communication network **270** may provide targeting device **202** with connectivity to network services, such as Internet services, for example.

(24) Communication network **270** may be configured to support communications between targeting device **202** and remote server **260** in accordance with any suitable number and/or type of wired and/or wireless communication protocols. Examples of suitable communication protocols may include personal area network (PAN) communication protocols (e.g., BLUETOOTH), Wi-Fi communication protocols, radio frequency identification (RFID) and/or a near field communication (NFC) protocols, cellular communication protocols, Internet communication protocols (e.g., Transmission Control Protocol (TCP) and Internet Protocol (IP)), etc.

(25) In another embodiment, targeting device **202** need not communicate with one or more of mobile devices **250** and/or remote server **260**. For example, targeting device **202** may operate as a standalone rangefinding, positioning, and navigation device that is carried and operated by a user to perform various functions.

(26) Targeting device **202** may be implemented as any suitable type of portable and/or mobile electronic device configured to function as a rangefinding and target positioning system. Embodiments include targeting device **202** implementing any suitable combination of these functions. Targeting device **202** may implement some of these functions without implementing others.

(27) In an embodiment, targeting device **202** may include a rangefinder **204**, a communications module **210**, a memory unit **212**, a display **216**, one or more processors **218**, and orientation determining component **220**, and a camera **222**. Targeting device **202** may further include a power source **224** and/or User Controls **226**. Targeting device **202** may include additional elements such as, for example, memory controllers, memory card slots, ports, interconnects, etc., which are not described herein for purposes of brevity.

(28) Communications module **210** may be configured to support any suitable number and/or type of communication protocols to facilitate communications between targeting device **202** and one or more of mobile devices **250** and/or remote server **260**. Communications module **210** may be configured to receive any suitable type of information via one or more of mobile devices **250** and/or remote server **260**. Communications module **210** may be implemented with any suitable combination of hardware and/or software to facilitate this functionality. For example, communications module **210** may be implemented with any number of wired and/or wireless transceivers, ports, connectors, antennas, etc.

(29) Communications module **210** may be configured to facilitate communications with various mobile devices **250** and/or servers **260** using different types of communication protocols. For example, communications module **210** may communicate with a mobile computing device via a wireless Bluetooth communication protocol (e.g., via wireless link) and with a laptop or a personal

computer via a wired universal serial bus (USB) protocol (e.g., via a wired link). To provide another example, communications module **210** may communicate with a traffic aggregation service via network **270** using a wireless cellular protocol. Communications module **210** may be configured to support simultaneous or separate communications between two or more of mobile devices **250** and/or remote servers **260**.

(30) As further discussed below, a user interface **502** may be configured to facilitate user interaction with targeting device **202** and/or to provide feedback to a user. In an embodiment, a user may interact with user interface **502** to change various modes of operation, to initiate certain functions, to modify settings, set options, etc., which are further discussed below.

(31) For example, user interface **502** may include a user-input device such as an interactive portion of display **216** (e.g., a "soft" keyboard, buttons, etc.) displayed on display **216**, physical buttons integrated as part of user controls **226** of targeting device **202** that may have dedicated and/or multi-purpose functionality, etc. To provide another example, user interface **402** may cause visual alerts or icons to be displayed via display **216** and/or audible alerts to be sounded. Audible alerts may be sounded using any suitable device, such as a buzzer, speaker, etc., which are not shown in FIG. **2** for purposes of brevity.

(32) Display **216** may be implemented as any suitable type of display configured to facilitate user interaction, such as a capacitive touch screen display, a resistive touch screen display, etc. In various aspects, display **216** may be configured to work in conjunction with user controls **226** and/or processor **218** to detect user inputs upon a user selecting a displayed interactive icon or other graphic, to identify user selections of objects displayed via display **216**, etc. In alternative embodiments, display **216** is not configured to accept user interaction, and is merely used as a visual output device. In such cases, user control of the device may be achieved, for example, using user controls **226** and or controlled remotely from a mobile device **250** and/or remote server **260**.

(33) In some embodiments, communications module **210** may be configured to utilize any suitable communications protocol to facilitate determining a geographic location of targeting device **202**. For example, communications module **210** may be configured to communicate with one or more satellites **280** and/or wireless transmitters in accordance with a Global Navigation Satellite System (GNSS) protocol, to determine a geographic location of targeting device **202**, and to generate geographic location data. Wireless transmitters are not illustrated in FIG. **2**, but may include, for example, one or more base stations implemented as part of communication network **270**.

(34) For example, communications module **210** may be configured to utilize "Assisted Global Positioning System" (A-GPS), by receiving communications from a combination of base stations (that may be incorporated as part of communication network **270**) and/or one or more from satellites **280**. Examples of suitable global positioning communications protocol may include Global Positioning System (GPS), the GLONASS system operated by the Russian government, the Galileo system operated by the European Union, the BeiDou system operated by the Chinese government, etc.

(35) Additionally or alternatively, in embodiments communications module **210** may receive a geographic location of the system **200** from one or more mobile devices **250**. Each or any of the mobile devices **250** may be configured to utilize any suitable communications protocol to facilitate determining a geographic location, as described above. In a particular example, a mobile device **250** may be a smart phone of the user **102** that determines the geographic location of the system via an integrated GPS receiver, and is operable to transmit that geographic location to the targeting device **202** via communications module **210**. This is intended only as example, and is not intended to be limiting. Any sort of location capturing technique performed through the use of communications module **210** is intended for inclusion within embodiments.

(36) Processor **218** may be implemented as any suitable type and/or number of processors, such as a host processor of targeting device **202**, for example. To provide additional examples, processor **218** may be implemented as an application specific integrated circuit (ASIC), an embedded

processor, a central processing unit (CPU) associated with targeting device **202**, a graphical processing unit (GPU), etc. Processor(s) **218** may be configured to communicate with one or more of communications module **210**, a memory unit **212**, a display **216**, rangefinder **204**, camera **222**, and orientation determining component **220**, via one or more wired and/or wireless interconnections, such as any suitable number of data and/or address buses, for example. These interconnections are not shown in FIG. **2** for purposes of brevity.

(37) Processor **218** may be configured to operate in conjunction with one or more of communications module **210**, a memory unit **212**, a display **216**, and orientation determining component **220**, to process and/or analyze data, to store data to memory unit **212**, to retrieve data from memory unit **212**, to display information on display **110**, to receive, process, and/or interpret signals from rangefinder **204**, to process user interactions via user controls **226**, to receive and/or analyze live video data captured via camera **222**, to receive data from and/or send data to one or more of mobile devices **250** and/or remote server **260**, etc.

(38) In accordance with various embodiments, memory unit **212** may be a computer-readable non-transitory storage device that may include any suitable combination of volatile memory (e.g., a random access memory (RAM) or non-volatile memory (e.g., battery-backed RAM, FLASH, etc.). Memory unit **212** may be configured to store instructions executable on processor **218**, such as the various memory modules illustrated in FIG. **2** and further discussed below, for example. These instructions may include machine-readable instructions that, when executed by processor **218**, cause processor **218** to perform various acts as described herein. Memory unit **212** may also be configured to store any other suitable data used in conjunction with targeting device **202**, such as data received from one or more of mobile devices **250** and/or remote server **260** via communications module **210**, range estimates from rangefinder **204** and information processed by processor **218**, image data from camera **222**, cartographic data **214**, data indicative of target locations and range envelopes by geographic location, etc.

(39) Memory unit **212** may include a first portion implemented as integrated, non-removable memory and a second portion implemented as a removable storage device, such as a removable memory card. For example, memory unit **212** may include a SD card that is removable from targeting device **202** and a flash memory that is not removable from targeting device **202**. Data may be transferred from a first portion of memory unit **212** (e.g., buffered live camera data) to a second portion of memory unit **212**, thereby allowing a user to remove a portion of memory unit **212** to access viewing data stored thereon on another device.

(40) Orientation determining component **220** may include one or more inclinometers, gyroscopes, accelerometers, etc. In embodiments, orientation determining component **220** may include a compass heading sensor, dead reckoning system, altimeter, or any other instrumentation that may be operable to provide information to processor **218** indicative of the orientation of targeting device **202**. Alternatively, images captured by camera **222** could be used to provide orientation data to processor **218** in embodiments.

(41) FIG. **3** shows a perspective view of an example targeting device **202** that may be included in embodiments. The embodiment of FIG. **3** is intended for example only, and is not intended to be limiting. The targeting device **202** may be alternatively embodied as a digital camera, incorporated into a handheld communication device or gun-like housing, or may be shaped as any other form and/or included as part of any other electronic device. In the embodiment shown in FIG. **3**, a lens assembly **302** is provided for targeting a target, projecting one or more pulses, receiving reflections of the one or more pulses, and in some embodiments capturing an image of the scene including the target and its proximity with a digital camera. In some embodiments, any of these functions may be performed by separate lens assemblies, while in other embodiments some of these functions may be omitted altogether. Display **216** may be provided at the rear of the device **202** illustrated in FIG. **3** for user input, information output, and/or targeting.

Example Procedures

(42) In embodiments, memory unit **212** includes instructions that, when executed by processor **218**, cause processor **218** to adjust one or more operating parameters and perform a rangefinding operation on a target based, at least in part, on the one or more operating parameters. In the discussion below, the user **102** will be exemplified as a golfer and the target will be exemplified as a flagstick **106** on a golf course, but this is not intended to be limiting. Embodiments may be utilized by any user **102** to perform rangefinding operations using adjusted operating parameters.

(43) Returning to FIG. **1**, a user **102** playing a hole of golf may use targeting device **202** to provide a range estimate of the distance to target flagstick **106** on green **104**. In general, a rangefinding operation is performed by rangefinder **204** in targeting device **202** by emitting one or more pulses towards target **106** with transmitter **206** and receiving reflections of the one or more pulses from the target using receiver **208**. For example, the pulses may provide a visible or infrared laser, which may be projected incident upon a target and reflected back to be captured by the receiver **208**. Processor **218** may then calculate a range estimate to the target **106** and display a representation of this estimate to the user **102** on display **216**. As further discussed below, the representation of the range estimate displayed on display **216** may include a distance to the target and/or a placement of an image representing the location of the target on a displayed map or image of the scene.

(44) The target flagstick **106** has a small horizontal area for targeting and is, in many cases, a significant distance away from the user **102**. For example, the flagstick **106** may only be about 4 centimeters in width, but may be 80 meters away. The result of this geometry is that the rangefinder **204** may capture many reflections of pulses from objects other than target **106**, such as foreground tree **110** or background trees **112** illustrated in FIG. **1**. These are intended only as examples, and are not limiting. Unwanted reflections may come from any object within a proximity of a line traveled by a "beam" of pulses between transmitter **206** and target **106**, objects beyond target **106** in cases where the beam "misses" the intended target flagstick **106**, e.g. slightly to the left or right, or optical scattering effects by the atmosphere. Captured reflections from such unintended targets create noise and corresponding incorrect range estimates that must be accounted for by processor **218** to give an accurate range estimation to target **106**.

(45) One exemplary method **400** of accounting for reflections from unintended targets is illustrated in FIG. **4**. In an embodiment, method **400** may be performed by any suitable combination of one or more processors, applications, algorithms, and/or routines, such as processor **218** executing instructions stored in one or more memory units **212**, for example, as discussed above for FIG. **2**. Further in accordance with such an embodiment, method **400** may be performed by one or more processors working in conjunction with one or more components within a mobile device, such as one or more processors **218** working in conjunction with one or more of communications module **210**, mobile device(s) **250**, remote server **260**, etc. The steps of method **400** may be performed in any reasonable order. Method **400** is only one example of an embodiment and is not intended to be limiting.

(46) Method **400** begins at step **402**, in which transmitter **206** of rangefinder **204** emits a pulse of a laser towards target **106**. The laser pulse travels a path from targeting device **202** towards target **106** until it strikes an object, which may be the intended target **106** or an unintended target such as trees **110,112**. Regardless of what object is struck, at step **404**, receiver **208** of rangefinder **204** captures a reflection of the laser pulse and provides data to one or more processors **218**. Processor **218** may then calculate a range estimate based on the provided data, indicative of the range and/or position of the object that was struck by the laser.

(47) In the case where the laser struck the intended target flagstick **106**, the rangefinding operation has, at this point, successfully calculated a range estimate of the target that may be displayed to the user **102** via display **216**. However, if the laser struck an unintended target, the calculated range estimate will be wrong, and displaying this estimate to the user **102** may cause him to miss badly on a subsequent golf shot. In many cases, a range estimate based on a laser reflection from an unintended target may differ from the actual distance to the intended target by many meters.

(48) If the exact geographic location of the target flagstick **106** could be retrieved from cartographic data **214** stored in memory unit **212**, the approximate distance between the targeting device **202** and target flagstick could be calculated based on a sensed geographic location of the device, and range estimates differing from this approximate distance could be simply disregarded by processor **218**. Unfortunately, the location of target flagstick **106** usually changes from day to day, as the hole is moved to provide different challenges for golfers. This variable position of the target means that cartographic data **214** stored in memory **212** (and/or retrieved from mobile device **250** or remote server **260**), cannot, in such cases, reliably indicate the absolute geographic location of the target flagstick **106**.

(49) However, the location of flagstick **106** will always be somewhere on green **104**, which does not move. Embodiments make use of this constraint on the possible position of target flagstick **106** by determining, based on cartographic data **214**, a range envelope of the target flagstick **106**. A range envelope provides an indication of the expected position of a target, and may be defined by a minimum range from the geographic location of the system to the target and a maximum range from the geographic location of the system to the target. In the example situation illustrated in FIG. **1**, the range envelope extends from the front **120** of green **104** to the back **130** of green **104**. The minimum range could, in an embodiment, be calculated for the illustration of FIG. **1** as the distance between the sensed geographic location of the targeting device **202** of the system **200** and the closest point on the green **120**. Similarly, the maximum range could be calculated as the distance between the sensed geographic location of the targeting device **202** of the system **200** and the furthest point on the green **130**. These minimum and maximum ranges could then define a range envelope for filtering out bad range estimates using processor **218**.

(50) Returning to method **400** of FIG. **4**, at step **406** processor **218** determines a range envelope of expected range estimates of the target flagstick **106**. In embodiments, step **406** is performed by receiving a sensed geographic location of the system from communications module **210** and finding minimum and maximum ranges for the expected position of the target **106** based on cartographic data **214** stored in memory unit **212**. As discussed above, communications module **210** may be operable to sense the geographic location of the system itself, and/or may be operable to communicate with one or more mobile devices **250** to obtain the sensed geographic location of the system.

(51) At step **408**, the processor(s) **212** calculates a range estimate of the target based on the laser transmitted and received by rangefinder **204**. The range estimate is then compared to the range envelope in step **410**. In the embodiment of method **400**, the range estimate is disregarded if it does not fall within the range envelope at step **412**, and a new measurement may occur. If, however, the range estimate does fall within the range envelope, it may then be displayed to the user via display **216** as a distance measurement and/or indicated position on a map.

(52) The steps of method **400** are only one example of a positioning procedure that embodiments may perform, presented for illustration. In general, in embodiments cartographic data **214** and the geographic location of the system are used to determine a range envelope for a target. Based on the range envelope, at least one operating parameter of the system is then adjusted to improve, speed, and/or support performance of the system. A rangefinder may then be used to perform a rangefinding operation on the target based on the one or more operating parameters.

(53) In embodiments processor **218** may adjust an operating parameter before, during, or after the transmission and reception of a laser pulse, depending on which operating parameter is being adjusted. For example, in the example discussed with regard to method **400**, the adjusted operating parameter is the maximum and minimum acceptable distances to a calculated range estimate. In this case, the operating parameter is used after a pulse reflection is received to determine whether or not the resulting range estimate should be disregarded.

(54) In alternative embodiments, the adjusted operating parameter may be the burst rate or power level of the transmitter **206**, which may likely be adjusted prior to transmission. For instance, the

power level of the transmitter may be increased for a range envelope that is very far away. In yet another embodiment, the measurement period of the rangefinder may be an adjusted operating parameter. This list of operating parameters is not meant to be exhaustive. Any operating parameter such as burst rate of one or more pulses transmitted by transmitter **206**, processing gain of processor **218**, measurement period, power level of transmitter **206** and/or any other parameter that may advantageously affect the operation of the system may be adjusted. An embodiment may adjust any or all of these operating parameters one or more times to perform a rangefinding operation.

(55) In some embodiments, the system **200** may perform a plurality of range estimates based on many transmissions and/or receptions of pulses by rangefinder **204**. In such embodiments, each particular rangefinding operation may produce a single range estimate, which may be disregarded if it calculates a position of the target that is outside the range envelope. Each acceptable range estimate may be stored in memory unit **212** to collect a set of possible range estimates. In some embodiments, the set of range estimates may be averaged to determine a specific range estimate to be displayed to user **102** via display **216**. In another embodiment, the range estimate that has been calculated the greatest number of times in the set of range estimates may be displayed to user **102**.

(56) In other embodiments, multiple range estimates may be collected until a threshold number of range estimates agree on a specific range estimate, which is then presented to user **102** via display **216**. In such an embodiment, the threshold number may be a static value stored in memory unit **212** or may be a value that is determined dynamically based on sensed parameters by processor **218**. For instance, the threshold value for range estimates in the set that must agree on a particular range estimate before it is displayed to user **102** may be set very high for a range envelope that is within 20 meters, because at such short range a highly accurate range estimate can both be expected and achieved. This is intended only as one example—any sensed parameter may be used by processor **218** to dynamically select a threshold number of range estimates that must agree before a particular range estimate is displayed to user **102** via display **216**.

(57) In another embodiment, range estimates outside the range envelope may not be disregarded by processor **218**, but rather included in the set of possible range estimates stored in memory unit **212**. In such an embodiment, processor **218** may select a higher threshold number for range estimates outside the range envelope. In this way, a specific range estimate to be displayed to user **102** via display **216** may be outside the calculated range envelope, accounting for inaccuracy in the cartographic data **214** and/or sensed geographic position of the system, but only if the confidence level of that specific range estimate is very high. In this embodiment, the threshold number for range estimates within the range envelope may be much lower, because these estimates fall within the region in which the target is expected to be.

(58) In embodiments the range estimate may be displayed on a synthetic vision display, such as illustrated on display **216** of FIG. **5**. A synthetic vision display may show terrain, obstacles, and other landmarks in their proximity to the user **102**. The synthetic vision display shows the terrain as it appears from the user's perspective, such as background trees **112**. The synthetic vision display may also assist the user in low-visibility situations, such in foggy conditions or when attempting a blind shot from behind a tree. The synthetic vision may provide an overlaid map **502**, presenting, at least in part, information stored in cartographic data **214** for the hole and nearby proximity of the system. The map may include an icon **504** indicating the current sensed geographic location of the system. Once a target position determination has been performed, an indication of the range estimate of the target may be presented on the display to user **102** as pin icon **506** or range estimate **508**. These examples are intended neither as exclusive nor limiting. Any representation of the range estimate of the target that may be displayed to a user via display **216** is intended for inclusion within embodiments. In some embodiments, the representation of the range estimate is not overlaid on an image or map, and is merely displayed as an alphanumeric output to the user. In some embodiments, the representation may be displayed to the user via a display of a mobile device **250**.

(59) A targeting graphic **510** may be shown on the synthetic vision display so as to supplement the map data and other data that is typically displayed on the synthetic vision display. It should be appreciated that in embodiments, the display **216** may also display known parameters **512** of the target **106**, such as the hole number, par, the cardinal direction heading, the altitude, and other parameters. Distances and other measured values may, of course, be presented to the user in any appropriate unit such as meters, feet, yards, etc. As such, the targeting graphic **510** may be displayed on the synthetic vision display as indicative of these parameters. In other embodiments, the system may include a camera **222** for taking a picture or video of the target **106** and displaying these elements along with picture or video on the synthetic vision display.

(60) The display of the picture or video presented to user **102** on display **216** may provide information overlaid on the display **216** assisting a user **102** in locating the target. For example, in the synthetic display illustrated in FIG. **6**, an aiming reticle **602** is displayed to user **102**, surrounding the location where transmitter **206** will project a pulse when the rangefinder **204** performs a rangefinding operation.

(61) As seen in FIG. **7**, a synthetic display may include an overlaid target assist icon such as flag icon **710** to assist a user **102** in recognizing the location of target flagstick **106** in an image captured by camera **222**, as further discussed below. Further, FIG. **7** displays another representation of a range estimate that may be presented to a user **102** on display **216** when a position determination has been performed. Icons **702** and **704** indicate visually to the user the estimated positions of the targeting device **202** and target flagstick **106**, respectively. Icons **706** and **708** provide additional information to the user via display **216**, that of the approximate locations of the minimum and maximum ranges from the geographic system of green **104**, which may define the range envelope. As seen in FIG. **7**, the range estimation of "158 m" is displayed above flag icon **710**, presenting yet another representation of the range estimate of the target flagstick **106**.

(62) It should be appreciated that, as used herein, "icon" and "graphic" may refer to any graphical representation of the respective information. An "icon" or a "graphic" may include graphics, pictures, photographs, words, numbers, symbols, lines, colors, opacity, cross-hatching, and other fill textures and visual representations of information. The "icon" or "graphic" may also change, alter, update, and delete as new information is obtained. For example, flagstick icon **506** and/or range estimate **508** may not appear until a range estimate is calculated. As such, the size, shape, location, orientation, and other aspects of the display may update as this new information is obtained (e.g., as a range estimate is calculated).

Modes of Operation

(63) In embodiments, processor **218** may cause the system, and in particular targeting device **202**, to enter a mode of operation in response to an activation. The activation may come from instructions programmed into memory unit **212**, a manual input by user **102** through user controls **226** or display **216** (in the case of a touch screen display), and/or may be provided automatically by sensory components of system **200** in response to one or more sensed parameters. Sensed parameters may include the orientation of the system as obtained from orientation determining component **220**, camera **222**, and/or the geographic location of the system as obtained from communications module **210**.

(64) Upon entering a mode of operation, processor **218** may adjust one or more operating parameters, influencing the position determining and range measurement methods disclosed. As previously discussed, such operating parameters may include the processing gain of processor **218**, a measurement period, and/or the burst rate or power level of transmitter **206**. The operating parameter(s) adjusted may depend on the mode entered, as well as one or more sensed parameters of the system, in embodiments. Further, embodiments may adjust an operating parameter upon entering a mode of operation, and then readjust the same operating parameter based on a range envelope determined based on the geographic location of the system and cartographic data **214**. Additionally or alternatively, embodiments may adjust an operating parameter upon entering a

mode of operation, and the adjust a different operating parameter based on a range envelope determined based on the geographic location of the system and cartographic data **214**. Entering a mode of operation may be done at any point during a rangefinding and position determining process performed by system **200**.

(65) For example, processor **218** may use an accelerometer functioning as an orientation determining component **220** in an embodiment to sense that targeting device **202** is being held very still while user **102** uses user controls **226** to cause transmitter **206** in rangefinder **204** to generate pulses of a laser. The accelerometer may, in such a situation, measure a lack of movement in the orientation of the rangefinder except for natural hand jitter of the user **102**. Additionally or alternatively, a compass heading sensor and/or inclinometer functioning as orientation determining component **220** may indicate to processor **218** that user **102** has operated the targeting device **202** in a steady, held position for a given amount of time. Processor **218** may, in response to a "holding" sensed orientation from orientation determining component **220**, follow instructions stored in memory **212** to cause system **200** to enter a mode of operation known as a holding mode. Alternatively, user **102** may press a button or turn a knob comprising user controls **226** to manually cause system **200** to enter a holding mode.

(66) During a holding mode, the user **102** is presumed to be targeting the target flagstick **106** directly, possibly because the flagstick is nearby and/or visible. In such conditions, processor **218** may perform rangefinding operations with lower power pulses, increased measurement rates, and approximate range data fed directly to display **216**, as illustrated in FIG. **5**. This is only a single example, and not intended to be limiting. In another embodiment, upon entering a holding mode, processor **218** may adjust operating parameters to increase the beam spread of the rangefinder **204** such that a portion of the beam generated by transmitter **206** is more likely to hit the target flagstick **106**. Processor **218** may, in such an embodiment, physically adjust lens assembly **302** to allow more beam smear during a measurement. Additionally or alternatively, the number of integrated pulses per measurement may be decreased by processor **218**, lowering processing gain to increase an effective measurement rate of system **200** with a smaller penalty in its sensitivity. In embodiments of system **200**, any particular operating parameter may be adjusted upon entering a holding mode of operation to improve, speed, and/or support an estimation of the distance to a target. In particular, upon entering a holding mode, an operating parameter may be adjusted to account for hand movement of a user **102** holding the system **200**.

(67) If, instead of a holding state, orientation determining component **220** senses a steady motion of targeting device **202** across a scene, processor **218** may follow instructions stored in memory **212** to cause system **200** to enter a mode of operation known as a scanning mode. Alternatively, user **102** may press a button or turn a knob comprising user controls **226** to manually cause system **200** to enter a scanning mode. A scanning mode may be useful in situations where the target flagstick **106** is difficult to target and/or far away. A user may operate targeting device **202** in a scanning mode to sweep the targeting device **202** across the entire green **104** of a golf hole, intending for the beam generated by rangefinder **204** to, at some point during the sweeping motion, successfully hit the target flagstick **106**.

(68) In response to entering a scanning mode, an operating parameter may be adjusted by processor **218** to improve the likelihood that the rangefinder successfully hits the target, and that the reflection from that hit is successfully captured and selected for display to the user **102** via display **216**. For instance, in an embodiment, processor **218** may maximize integration time and/or burst repetition rates while in a scanning mode, causing a longer processing delay and power requirement, but a more robust range estimate. Again, this is only one example the manner in which operating parameters that may be adjusted upon entering a scanning mode. Any operating parameter adjusted in any way in response to entering a scanning mode to improve, speed, and/or support an estimation of the distance to a target is intended for inclusion within embodiments. In particular, upon entering a scanning mode, an operating parameter may be adjusted to account for a

scanning motion of the system **200**.

(69) In an embodiment, processor **218** may cause system **200** to enter a mode of operation constituting an aiming mode, operable to assist user **102** in locating, targeting, and/or successfully hitting target flagstick **106** with one or more pulses from transmitter **206**. For example, illustrated in FIG. **6** is a synthetic display that may be displayed to user **102** via display **216** when processor **218** causes system **200** to enter an aiming mode of operation. FIG. **6** is only one example, and is not intended to be limiting. Aiming reticle **602** is presented, overlaid on an image captured by camera **222** to assist user **102** in finding target flagstick **106** in the midst of other objects, and possibly from a great distance. In some embodiments, the image presented to user **102** via display **216** may be zoomed by processor **218** relative to the actual image captured by camera **222**. In another embodiment, processor **218** may steer aiming reticle **602** and/or the scene imaged by camera **222** in a direction relative the actual transmitter **206** pointing orientation based on accelerometer data of the targeting device **202**. This may imperceptibly drive the user **102** to aim the targeting device closer towards the location of the target flagstick **106**. Non-uniformity in the distribution of tremor-induced angular movement in azimuth and elevation as sensed by orientation determining component **220** relative to the center axis could be accumulated from previous uses in memory **212** to optimize the pointing orientation, making this method for appropriately usable with shorter effective measurement times.

(70) In another embodiment, processor **218** may cause system **200** to enter a mode of operation known constituting a target seek mode. Target seek mode may be initiated, for example, by the holding down of a measurement button on user controls **226** for an extended period. Alternatively or additionally, target seek mode may be entered automatically by processor **218** based on a combination of a cartographic data **214** from memory unit **212**, sensed geographic location provided by communications module **210**, and a sensed orientation of the targeting device **202** from orientation determining component **220**. For example, based on cartographic data **214** related to a hole and the sensed geographic location from communications module **210**, processor **218** may be able to conclude the direction targeting device **202** must point to perform a rangefinding operation on target flagstick **106**. Thereafter, if data from the orientation determining component **220** indicates that targeting device **202** is pointed in this direction, processor **218** may automatically cause system **200** to enter a target seek mode.

(71) As before, entering target seek mode adjusts an operating parameter to improve, speed, and/or support performance of the system. For instance, measurement rate may be increased to improve the likelihood that a valid distance is obtained as the transmit beam of pulses sweeps across flagstick **106** due to hand shake and/or the natural sweep of the beam as the user **102** sights to the target. Adjusted parameters may be any of those described above or any others that may be useful in assisting in identification of target flagstick **106**.

(72) Upon entering target seek mode, processor **218** may additionally capture, using camera **222**, an image of the proximity of target flagstick **106** and search pixels of the image for information indicative of target flagstick **106**. For example, video processing by processor **218** of a central grouping of pixels captured by camera **222** can be used to identify and locate the flag and pole, providing a steady anchor for any superimposed display information on display **216** and helping to steer the user **102** into the flag location if there is an angular bias between apparent azimuth and elevation to the flag location and the actual line-of-sight of the rangefinder. In some embodiments, processor **218** may capture the location of target flagstick **106** by processing pixels in an image captured by camera **222** and display a flag icon **710** overlaid on the image on display **216**. This may be particularly useful for assisting the user **102** in targeting during dark, misty, or foggy conditions. Overlaying a flag icon **710** may indicate a "pin lock" condition, that processor **218** has confidently located the target flagstick **106** and is prepared to make or has made an accurate range estimate. Once a pin lock condition is reached, if a user control **226** button remains depressed, processor **218** may cause labels, icons, or other graphics displayed on display **216** to remain fixed

firmly in place even if user **102** scans the rangefinder away from the flagstick **106** to view other locations on the green **104**.

(73) Flag icon **710** is only one example of a target assist icon that may be presented to the user **102** while in target seek mode. Additionally or alternatively, a cross-hair icon or reticle such as aiming reticle **602** could be presented to user **102** on display **216** to assist in finding and targeting flagstick **106**. In some embodiments, processor **218** may use the cartographic data **214**, sensed geographic location of the system, and orientation data of the system to display a target assist icon on display **216** indicative of a direction to turn the device towards the target. For instance, given a known location and heading on a golf course from communications module **210** and orientation determining component **220**, processor **218** could be operable to determine that a user **102** is pointing a targeting device too far to the left to be able to successfully perform a rangefinding operation on the target. Processor **218** may then be operable to display an arrow pointing to the right on display **216**, informing the user that they should point targeting device further to the right. The arrow constitutes a target assist icon, which in embodiments may be flashing, colored, or presented in any other attention-grabbing form.

(74) In some embodiments, a spatial filtering algorithm may be employed and may be optimized based on the range envelope. As a particular example, the sharp vertical and angular outline of the pole and flag of flagstick **106** may be distinctive spatially relative to the softer gradations and curved shapes of the natural background. A 0.75 inch diameter, 6 foot tall flag pole at 250 yards provides a subtended azimuth angle of roughly 80 microradians and an elevation angle of 7.8 milliradians. Assuming approximately 480 camera pixels for a 6-degree field of view (FOV), a FOV per pixel is 200 microradians. Thus, a one or two pixel wide vertical line roughly 40 pixels tall of flagstick **106** would be seen by camera **222**.

(75) This rectangular block of pixels surrounding the center of the target field may then be processed to create high contrast and to emphasize distinguishing spatial characteristics between the flagstick **106** and the background scene First, the scene is processed to remove the dominate scene color (likely green) to improve contrast between the background and the normally distinguishing pole and flag color. The image is then converted to grayscale to simplify downstream convolutional processing. The block of data is then spatially filtered using a convolution operator to accentuate narrow vertical features in the scene followed by a thresholding operation to eliminate background clutter and pixel noise. Finally the image block is processed using convolution using an edge detection operator with an associated detection criteria based on the degree of match between shapes in the field and the expected shape. The detection criteria could be based on distance because the maximum height of the pole relative to the horizon is known, and thus the criteria needed to calculate its vertical pixel extent. In most cases, the pixel subregion could be limited to a less than 10 pixels wide by 100 pixels tall, taking into account the presence of pointing uncertainty and hand jitter relative to targeting graphic **510**.

(76) Embodiments may use reflectivity to improve the accuracy of position determinations. As shown in FIG. **8**, the reflectivity of common terrestrial materials likely to encountered around the golf course and their dependence on optical wavelength may be stored in memory unit **212** of the targeting device **202**. In embodiments, the reflectivity of such materials may be used by processor **218** to select a wavelength for transmission by transmitter **206** or determine a successful capture of an optical reflection from a target flagstick **106**.

(77) While reference has been made above to the various components and techniques of embodiments, the description that follows will provide further examples systems and processes that may be added in embodiments. The description below is intended to merely exemplify steps that may be taken in practice of operation of the embodiments and is not intended to be limiting. Steps that may be performed in practice of some embodiments are illustrated in FIG. **9** and herein described.

(78) Turning now to FIG. **9**, a flowchart illustrating the operation of a method for determining a

position of a target is depicted and referred to generally by reference numeral **900**. At step **902**, processor **218** receives the geographic location of the system from communications module **210**. As discussed above, communications module **210** may be a GPS receiver, operable to sense the geographic location of the system itself, and/or may be operable to communicate with one or more mobile devices **250** to obtain the sensed geographic location of the system. At step **904**, the system **200** retrieves cartographic data **214** for the sensed geographic location, which may already be stored in memory **212** or may be requested from mobile device **250** and/or remote server **260**. At step **906**, the processor **218** receives orientation data of the system from orientation determining component **220**. Steps **902**, **904**, and **906** may be performed in any order or simultaneously, though in most cases it is envisioned that reception of the geographic location in step **902** would be performed prior to retrieval of cartographic data **214** in step **904**.

(79) Similarly, steps **908** and **910** may be performed in any order or simultaneously. At step **908**, processor **918** uses the geographic location of the system and the cartographic data **214** to determine a range envelope for the target, such as target flagstick **106**. The range envelope may be defined by a minimum range from the geographic location of the targeting device **202** and a maximum range from the geographic location of the targeting device **202**. In step **910**, processor **218** causes system **200** to enter a mode of operation, which may be in response to the sensed orientation of the system and sensed geographic location of the system. In some embodiments, entering a mode of operation may further or alternatively be in response to a manual activation by a user and/or an image captured by camera **222** and subsequently processed by processor **218**. In response to entering a mode of operation, at step **912** a first operating parameter is adjusted based on the entered mode. Similarly, in step **914** a second operating parameter is adjusted in response to the determined range envelope. The first and second operating parameters may be the same or distinct operating parameters in embodiments, and in the case of distinct parameters may be adjusted in any order.

(80) Transmitter **206** in rangefinder **204** then transmits one or more pulses as a beam of light towards target flagstick **106** in step **916**. In step **918**, reflections of the pulses are received by receiver **208** and provided to processor **218**. Processor may then calculates a range estimate in step **920**, completing a rangefinding operation. The rangefinding operation is based, at least in part, on the first and second operating parameter adjustments. A representation of the range estimate is then displayed to a user **102** in step **922**, and in some embodiments may be stored in memory unit **212**.

(81) It should be appreciated that, while the above disclosure is directed mainly to the field of golf, some embodiments may be employed for any field requiring accurate distance measurement to a target that is located in a known area. Embodiments and techniques may be used in any setting or field, such as hunting, aeronautics, and archery. Embodiments and techniques may be particularly applied to military applications, such as targeting munitions at a target within a area having known dimensions and position. The golf field discussed is merely exemplary and should not be construed as limiting.

(82) Although systems and methods for assisting a user with determining the distance to a target golf flagstick **106** have been disclosed in terms of specific structural features and acts, it is to be understood that the appended claims are not to be limited to the specific features and acts described. Rather, the specific features and acts are disclosed as exemplary forms of implementing the claimed devices and techniques.

Claims

1. A system for determining a range estimate to a target comprising: a rangefinder including: a transmitter operable to emit one or more pulses towards the target, and a receiver operable to receive reflections of the one or more pulses; a camera; a display; and at least one processor operable to: acquire an image from the camera, identify a target flagstick within the image acquired

from the camera, modify pixels proximate to the identified target flagstick of the image to generate a modified image contrasting the target flagstick from objects in the background by removing a scene color, converting the image to grayscale and spatially filtering a block of data associated with the pixels using a convolution operator to accentuate narrow vertical features depicted in the image, calculate a range estimate to the target flagstick using the rangefinder, and present, on the display, the modified image and a representation of the range estimate of the target flagstick.

2. The system of claim 1, wherein the processor is further operable to control the display to present information over the modified image.

3. The system of claim 2, wherein the processor is configured to control the display to present a flag icon over the target flagstick within the modified image.

4. The system of claim 1, wherein the processor is further operable to perform a thresholding operation to reduce background clutter and pixel noise.

5. The system of claim 4, wherein the processor is further operable to perform convolution using an edge detection operator with detection criteria based on a degree of match between shapes in a field of view and an expected shape of the target flagstick, the detection criteria based on the calculated range estimate to the target flagstick distance.

6. The system of claim 1, further including- a communications module operable to obtain a geographic location of the system, and a memory unit storing cartographic data, wherein the processor is operable to estimate the relative location of the target flagstick using the geographic location of the system and the stored cartographic data.

7. The system of claim 6, further including an orientation determining component for sensing an orientation of the system, and wherein the at least one processor includes an aiming mode for assisting a user in aiming the rangefinder at the target flagstick based on the orientation of the system and the geographic location of the system.

8. The system of claim 7, wherein the orientation determining component is selected from the group consisting of an inclinometer, a compass heading sensor, a gyroscope, and an accelerometer.

9. The system of claim 6, wherein the communications module is a GPS receiver.

10. The system of claim 1, further including a housing to integrate the rangefinder, camera, display, and processor.

11. A system for determining a range estimate to a target comprising: a rangefinder including: a transmitter operable to emit one or more pulses towards the target, and a receiver operable to receive reflections of the one or more pulses; a camera; a communications module operable to obtain a geographic location of the system; a memory unit storing cartographic data; an orientation determining component configured to sense an orientation of the system; a display; and at least one processor operable to: acquire an image from the camera, identify a target flagstick within the image acquired from the camera, modify pixels proximate to the identified target flagstick of the image to generate a modified image contrasting the target flagstick from objects in the background by removing a scene color, converting the image to grayscale and spatially filtering a block of data associated with the pixels using a convolution operator to accentuate narrow vertical features depicted in the image, calculate a range estimate to the target flagstick using the rangefinder, and control the display to present the modified image and a representation of the range estimate of the target flagstick; wherein the processor is operable to estimate the relative location of the target flagstick using the geographic location of the system and the stored cartographic data.

12. The system of claim 11, wherein the processor is configured to control the display to present a flag icon over the target flagstick within the modified image.

13. The system of claim 11, wherein the processor is further operable to perform a thresholding operation to reduce background clutter and pixel noise.

14. The system of claim 13, wherein the processor is further operable to perform convolution using an edge detection operator with detection criteria based on a degree of match between shapes in a field of view and an expected shape of the target flagstick, the detection criteria based on the

calculated range estimate to the target flagstick distance.

15. The system of claim 8, wherein the orientation determining component is selected from the group consisting of an inclinometer, a compass heading sensor, a gyroscope, and an accelerometer.

16. The system of claim 8, wherein the communications module is a GPS receiver.

17. The system of claim 8, further including a housing to integrate the rangefinder, camera, display, and processor.

18. A system for determining a range estimate to a target comprising: a rangefinder including: a transmitter operable to emit one or more pulses towards the target, and a receiver operable to receive reflections of the one or more pulses; a camera; a communications module operable to obtain a geographic location of the system; a memory unit storing cartographic data; an orientation determining component configured to sense an orientation of the system; a display; and at least one processor operable to: acquire an image from the camera, identify a target flagstick within the image acquired from the camera, modify pixels proximate to the identified target flagstick of the image to generate a modified image contrasting the target flagstick from objects in the background by removing a scene color, converting the image to grayscale and spatially filtering a block of data associated with the pixels using a convolution operator to accentuate narrow vertical features depicted in the image, calculate a range estimate to the target flagstick using the rangefinder, and control the display to present the modified image, a representation of the range estimate of the target flagstick and a flag icon over the target flagstick; wherein the processor is operable to estimate the relative location of the target flagstick using a geographic location of the system and the stored cartographic data.