Engineering a Device to Locate Golf Balls

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Introduction

The Game of Golf

Golf is a casual sport; it does not involve any running, and golfers can move at their own paces. Players start out in an area called the teeing ground and hit the ball with a club. The golfers then proceed to where they hit the ball by walking on foot or by riding in a golf cart/kart. Once the ball is hit into the hole in an area called the green, the same process is repeated eighteen times. The goal of golf is to complete the game with as few strokes as possible.

In order to make the game more interesting, obstacles and hazards are placed in various locations. The Official Rules of Golf state that a hazard is either water or a bunker, a sand trap in the ground. Trees and thick grass called rough are considered hazards by some people as well. The ball does not need to be directly on an obstacle to be considered in it. For example, the area around water is marked with flags, which indicate the land surrounding it within is a threat (Kelley, 2012). Figure 1 shows a typical golf course, with hazards surrounding it.

Figure 1. Golf course layout. Most golf courses comprise a landscape with trees, bunkers, and water (“TCU golf clubs”, n.d.).
Golf Ball Retrieval

Hence a need has become obvious for retrieving golf balls. Some people walk to them, while others with special licenses can pay to ride in a golf cart (“New rules for golf carts”, 2012). Locating the golf ball is not always straightforward. If the ball were hit in a patch of long grass, especially at a far distance, then it would be challenging to locate it. In any case where the ball cannot be retrieved, substitute golf balls with identification markers may be used. Even though golf balls may come in different colors, they all share the same basic design, as shown in Figure 2.

![Golf ball design. All golf balls have a core that is surrounded by a shell (“Wilson FG tour & C:25 golf balls”, n.d.).](image)

Past Golf Ball Detectors

Recently, golfers have expressed an interest in locating golf balls by using detectors. The cost per detector ranges depending on what materials the devices comprise.

There are several different kinds of golf ball detectors, and each uses a unique way to find the ball. One method involves photo imaging, which can only detect white balls. The ball needs to be at least 1% visible and within 10.7 meters of the device.
The handheld device called the Ballfinder Scout scans the surrounding area using a digital imaging system. When the ball is found, the Ballfinder Scout buzzes and an LED light is targeted towards the ball.

A third example is the Visiball ball finder, which is in the form of eye spectacles. It absorbs as much light as it can, but allows light to reflect off the ball. As a result, the ball will appear to be much brighter than its surroundings. Adaptions have been made for people that actually wear prescription glasses. The Visiball ball finder is less expensive to manufacture than the Ballfinder Scout (Bodamer, n.d.).

The Prazza Golf Ball Finder, shown in Figure 3, uses radio transmission. Only a handset and a proprietary golf ball are needed, which connect within a range of 100 meters. The golf balls emit a radio signal and the handset will receive it. The handset will then give the location of the ball, showing where it is on a screen and emitting sounds. The device will last up to eight hours with batteries. Figure 3 shows the Prazza Golf Ball Finder (“Prazza golf ball finder”, n.d.).
The idea of light detecting and ranging was considered on a few occasions. LIDAR detectors search for infrared laser pulses. Because of the thinness in the laser, LIDAR detectors are less accurate than other golf ball location devices (“How do laser detectors work?”, 2004).

Various applications that use GPS technology are increasing. There exist golf balls that have a GPS system already built into them, which lets the app user know the exact location of the ball. At least one golf-related project has been completed using GPS. Chris Savarese devised RadarGolf, a locating system for golf balls. Proprietary balls are installed with a microchip. A locating handheld uses GPS technology and will sync to the chip. Within a range of 9.14 to 30.5 meters, the handheld will emit sounds as it navigates closer to the golf ball (Grass, 2011).
Literature Review

Circuit Boards

Knowledge of how circuit boards work has become essential in engineering a device that can locate golf balls. Circuit boards contain chips that have metal prongs at the ends of them, as shown in Figure 4. The prongs send electrical discharges and travel through wires in the circuit board to other chips. The discharges do not occur all the time; at specific times a certain amount of electricity is passed. This results in mathematical computations that the majority of electronics use to carry out functions (Andrews, 2009).

Figure 4. Parts of a circuit board. A circuit board comprises electronic components, including prongs, buzzers, and oscillators (“Circuit boards / PCB”, n.d.).
Radio Transmitters

Progress in the area of manufacturing radio transmitters has created a surge in locating lost apparatus. Wireless instrument networks have been used for several years, being used only by the military when they first came out.

When wireless networks are set up, the type of transmission frequency needs to be decided, either licensed or unlicensed. From the U.S. Federal Communications Commissions, the licensed require an application procedure. The unlicensed have limits on the transmission of the highest power (Eren, 2006).

Radio transmitters are reliable and cost friendly, opening up even more possibilities. Several devices use them, ranging from microwaves to clocks. Even GPS technology uses radio waves to a certain extent; they transmit data to the satellites and the satellites return it. The technology is simple to set up (Brain, n.d.).

GPS Technology

Recent progression in science regarding global positioning systems has enabled its usage in navigation. When GPS first came out, it was rare and expensive. Ever since it has become one of the most widely used navigation apparatuses, the cost has been lowered. GPS works by having satellites orbiting the Earth send signals to a GPS receiver, which will return the signal. The United States relies on the satellite called Navstar. Other countries use different satellites because of their location. All of them orbit the Earth every twelve hours and operate at all times. 24 are in use at a time, and are 18,507.5 kilometers above Earth.

The signals contain information about the location and what time it is. All GPS devices transmit their data at the same time. The devices are accurate, and most will send the user within
ten meters of their destination. Some sources for error include the number of satellites being used at a time, objects in the way of transferring data, and receiver errors in the time (Griffin, 2011).

Today, some cars and other vehicles can guide themselves to a set destination. They require a vehicle, a controller, a traveling route, and the ability to be blocked in intersections. These destinations can be changed, so they are not always set to the same location. The guided systems can be turned off anytime (U.S. Patent No. 7,558,670, 2006).

A golf cart monitoring system has been proposed. The system uses radio transmitters and receivers, much like other location devices. It uses the basic areas of a golf course, including the fairway and the putting area. By using a sensor ID transmitting device, golf carts transfer information to one main receiver. A tablet displays information on the coordinates of the cart, and whether or not it is moving (U.S. Patent No. 6,348,007, 2002).

Original concepts for early navigation systems had the same premise – move by using a map programmed into the device. It would contain an input system and would display information regarding that information on a monitor. It would use coordinate points to move to the final destination, and would stop if the exact point was reached, or if another point that was very close to the original (U.S. Patent No. 4,796,189, 1989).

Most navigation devices for vehicles use GPS receivers, receivers, processors, a display page, and navigation data. The navigation data comprises information regarding altitude, velocity, and turns. The virtual display shows a map of the area, as well as other useful information, including the distance to the desired point (U.S. Patent No. 7,054,725, 2006).

GPS and golf can be combined to make the sport simpler and quicker for the player. One way is to show the player what the course layout is, including where large obstacles like water are. The other way is to find the distance between the golfer and the hole. Most GPS sets, such as
the ones in Figure 5, include a handheld device that can display maps. Multiple handhelds are in the development stages and will be installed into future golf carts/karts (Wa Wanjiru, n.d.).

![GPS receivers. There are several different types of GPS devices. When data is received, information is displayed on the screens of the majority (“GPS navigation device”, 2012).](image)

Some golf balls contain a built-in GPS system. The chip must be small enough so that the change in mass of the golf ball does not affect gameplay, but durable so that it does not break when the ball is stroked.

Numerous smart phones use GPS as well. However, they are not as reliable due to external noise and channel variation. Methods for fixing these issues are being worked on currently. The mobile service data will release codes, which will be used to remedy errors in Tx/Rx times. Figure 5 shows some GPS devices (U.S. Patent No. 8,111,650, 2008).
Bluetooth

Knowledge of Bluetooth technology has become essential in syncing new golf balls to the location devices. The purpose of Bluetooth is to perform technological tasks wirelessly, using one core system. The physical layer of a Bluetooth device uses a band that runs on 2.4 gigahertz, the same frequency Wi-Fi uses. It is managed with an RF topology allegedly called “star topology.”

When groups of devices are synced to the same frequency-hopping and clock patterns, radio stations can be shared. There is a principal device that is the basis for synchronization. For example, a smart phone could be the basis, while a GPS receiver and a car stereo are other devices in the group. Frequency-hopping patterns can use frequencies of intrusive mechanisms.

The wireless channels are divided into time slots, where data is transferred. At this moment, frequency-hopping takes place. The channels carry links for all types of data, ranging from audio files to calendars (Scientific american, 2007).

The principal device relies on signals from other devices to be able to connect. Once the signal has been received, a response will be sent from the main device to the other ones, allowing them to interact.

Engineering Plan

Researchable question or engineering problem being addressed:

Golf balls can be difficult to locate after they are driven by golfers, especially when they land at a far distance.
Engineering Goal:

The goal of this project is to build a location device to automatically locate the golf ball.

Description in detail of methods or procedures:

People can locate roughly anything by using sonar, radar, tagging, quantum dots, GPS, and radio transmission. Sonar is when objects emit a sound wave and the wave is reflected back at them, producing an echo. Sonar can travel for thousands of miles. Depending on the frequency of the echo, that is how animals know how big an organism or area is. Several animals with poor eyesight use it, especially underwater. Bats, dolphins, and whales are among them.

In radar, signals are sent between three radar installations, where they will ping in a triangular method. For example, in the golf project, the locations could be a tower, the ball, and the location handheld.

When animals become tagged, scientists can locate them at any given moment. Satellite tagging is used for mostly large animals. The purpose is so that scientists can research their migration patterns and movements. The process occurs between a satellite and a receiver. Data transmitted includes latitude, longitude, date, and time. This type of tagging is very expensive, at approximately $3,500 per tag. Two types of satellite tagging exist for marine organisms. One is instantaneous, and the other is when the organism surfaces. Archival tags are used to find out the living conditions of an animal, including their body temperature, heart rate, and light surroundings. Scientists study this so that they can find out how an organism reacts to changes in their environment. There is no way to transmit the data, so scientists must manually retrieve the tags (Goetz, 2012).
Quantum dots, or semiconductor nanocrystals, are micro-sized molecules that contain electrons. The number of electrons in a quantum dot varies from one to several thousand, where their dimensions and amount can be controlled. Depending on these changes, energy levels can change significantly. When connected to electrodes, they can be used to study atomic properties. Quantum dots are the result of when thin semiconductor films bend due to the difference in lattice structures that the films were originally formed. They are used in abundant electrical devices, including semiconductors for cascade lasers, injection lasers, quantum computers, semiconductors for photo detectors, and places for storing information (Mishra, n.d.). They can also be used for DNA testing, and rendering 3D models inside an organism. Quantum dots are valuable when it comes to methods of locations. When the semiconductors change, they emit unique colors. The colors can be used like a barcode in a super market, where each code is unique. They can be injected into components of the human body, like proteins and cells, to locate biomolecules (“Quantum dots - what are quantum dots, why are they important and what applications are they used in?”, 2005). Quantum dots are not widely used because they are relatively new and are expensive. In the future, however, they may be used on currency so that counterfeit money will become obsolete. Quantum dots would not be a good option for golf ball location, as the price to manufacture golf balls with them would be high.
When a golf ball is hit, acceleration occurs for a brief time. As shown in Table 1, the g-force was calculated.

<table>
<thead>
<tr>
<th>Realistic Values for the Situation</th>
<th>Obtaining the g-force</th>
<th>Obtaining applied force</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Initial Velocity = 0 m/s</td>
<td>• $V^2 = Vf^2 + 2a\Delta x$</td>
<td>• $F = ma$</td>
</tr>
<tr>
<td>• Final Velocity = 41 m/s</td>
<td>• $(41 \text{ m/s})^2 = (0 \text{ m/s})^2 + 2a (0.010 \text{ m})$</td>
<td>• $F = (0.046 \text{ kg}) (84050 \text{ m/s}^2)$</td>
</tr>
<tr>
<td>• Mass of ball = 0.046 kg</td>
<td>• $a = 84050 \text{ m/s}^2$</td>
<td>• $F = 3866.3 \text{ N}$</td>
</tr>
<tr>
<td>• How far the force was applied for (change in distance) = 0.010 m</td>
<td>• $G = a / g$</td>
<td>• $G = F / g$</td>
</tr>
<tr>
<td></td>
<td>• $G = (84050 \text{ m/s}^2) / (9.8 \text{ m/s}^2)$</td>
<td>• $G = (3866.3 \text{ N}) / (9.8 \text{ m/s}^2)$</td>
</tr>
<tr>
<td></td>
<td>• $G = 8576.53$</td>
<td>• $G = 394.52$</td>
</tr>
</tbody>
</table>

Three golf balls were be sliced exactly in half with a hacksaw. Two of them will be sealed up immediately after, to test the adhesive to be used. One will be sealed with superglue, and the other will be sealed with liquid metal. After one whole day of drying, the balls were hit with a golf club, into a blue hanging tarp (December 16, 2012, 2.22° C). The results were recorded.

Two more golf balls each had holes drilled into them to test if that would be a better method to install the chip rather than slicing the ball. One was drilled to the center with a radius of 0.35 cm and the other was drilled with a radius of 0.65 cm. The balls were hit with a golf club, into a blue hanging tarp (December 17, 2012, 3.89° C). The results were recorded.

The primary method to build the location device will be to install radio transmitters into a golf ball, with a combination of GPS. First, radio transmitters and GPS will be installed onto two
circuit boards. One will be the receiver, and the other will be the transmitter. The two boards will sync together, using Bluetooth technology.

In a golf ball, a circuit board transmitter will be installed. To make sure that the circuit board does not break when the golf ball is hit, the remaining space will be filled with a filling material. Once that is dried after 2 hours, the rest of the ball will need to be patched.

Using the receiver circuit board, a locating device will be engineered. A screen that will display the direction of the ball will be attached to the circuit board. A plastic mold will surround the two, so that only the screen will show.

In order to test the hypothesis, the ball that is synced to the circuit board will be moved about in various locations. The screen should have an arrow that points in the right direction.

The final results will most than likely be the best, but will be the most expensive.

The secondary method will be to install radio transmitters into a golf ball, without GPS. First, radio transmitters will be installed onto two circuit boards. One will be the receiver, and the other will be the transmitter. The two boards will sync together, using Bluetooth technology.

In a golf ball, a circuit board transmitter will be installed. To make sure the circuit board does not break when the golf ball is hit, the remaining space will be filled with a filling material. Once that is dried after 2 hours, the rest of the ball will need to be patched.

Using the receiver circuit board, a locating device will be engineered. A screen that will display the direction of the ball will be attached to the circuit board. A plastic mold will surround the two, so that only the screen will show.
In order to test the hypothesis, the ball that is synced to the circuit board will be moved about in various locations. The screen should have an arrow that points in the right direction. The final results might be the worst out of the three, but will easily be the least expensive.

The tertiary method will be to install just GPS into a golf ball. First, GPS will be installed onto two circuit boards. One will be the receiver, and the other will be the transmitter. The two boards will sync together, using Bluetooth technology.

In a golf ball, a circuit board transmitter will be installed. To make sure the circuit board does not break when the golf ball is hit, the remaining space will be filled with a filling material. Once that is dried after 2 hours, the rest of the ball will need to be patched.

Using the receiver circuit board, a locating device will be engineered. A screen that will display the direction of the ball will be attached to the circuit board. A plastic mold will surround the two, so that only the screen will show.

In order to test the hypothesis, the ball that is synced to the circuit board will be moved to various locations. The screen should have an arrow that points in the right direction.

The final results will be in the middle out of the three methods, and will be moderately expensive. A balance of these factors may be beneficial.
Methodology

Two circuit boards (BRAND, DIMENSIONS, WEIGHT) will have one GPS transmitter (BRAND, SIZE OF CHIP, WEIGHT, POSSIBLE RANGE) and one radio transmitter (BRAND, SIZE, WEIGHT, POSSIBLE RANGE) installed and soldered onto each of them. The devices will be synced together.

Three golf balls (Wilson brand, weight of 46 g, diameter of 42.7 mm, inner core made out of black proprietary material, diameter of 3.81 cm, volume of 28.94 cubic cm, outer shell made out of white thermoplastic) were cut exactly in half using a vice and a hacksaw (basement of the student). One of the balls was super-glued back together (Gorilla Brand, enough to cover 11.395 square cm), while a second one was sealed using liquid metal. After drying for two hours, both of them were taken outside (December 17, 2012, 3.89° C). A tarp was hung on a soccer net, so that the tarp was perpendicular to the ground beneath it. Both of the balls were hit by a golf club (Spalding brand, DIMENSIONS) into the tarp from a distance of 0.5 meters. The purpose was to test which adhesive would be better to use, and the results were recorded.

In the third golf ball, exactly ___ ounces of the core was cut out, and one of the circuit boards was put in the hole. A filling material called ___ (MATERIALS, HOW MUCH, WEIGHT, COLOR) was put around the chip on the half of the golf ball, making that side as flat as it was originally. It took ___ minutes for the sealer to dry. After, the two halves of the golf ball were fastened back together using ___ (BRAND, MATERIALS, HOW MUCH, WEIGHT, COLOR).

With the other circuit board, a location device was engineered. A screen (BRAND, WEIGHT, DIMENSIONS) was placed parallel to the circuit board. The two were connected by
The circuit board and the screen were fastened to a plastic mold (BRAND, COLOR, DIMENSIONS, WEIGHT).

Last, the golf ball with the circuit board will be placed in various locations, and the device will be tested.
Results

The golf balls will need to be as close to their original shape and weight as possible. The amount of displaced material, such as the core when the ball is sawed, will need to be minimal. The overall appearance of the golf ball should look no different than before.

The circuit board inside the chip will need to be tightly compacted so that it will not break. It will need to withstand at least 3866.3 N of force. The inside of the golf ball will need to use a sealant that will completely surround the chip, absorbing shock at the same time. If part of the shell of the golf ball was displaced, it will need to be replicated. Some of the criteria was put to a test, as shown in Table 2.

<table>
<thead>
<tr>
<th>Golf Ball Matrices</th>
<th>Max Points</th>
<th>Design 1</th>
<th>Design 2</th>
<th>Design 3</th>
<th>Design 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Efficiently fastens ball</td>
<td>10</td>
<td>?</td>
<td>0</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>2. Actual weight close to predicted</td>
<td>8</td>
<td>?</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>3. Golf balls can be hit the same distance as the originals</td>
<td>8</td>
<td>?</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>4. Easy to install chip</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Low cost/effort</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>6. Incision not noticeable</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>?</td>
<td>17</td>
<td>39</td>
<td>37</td>
</tr>
<tr>
<td>Percent</td>
<td>100%</td>
<td>?</td>
<td>39%</td>
<td>89%</td>
<td>84%</td>
</tr>
</tbody>
</table>

The prototype of the device will need to sync to the golf ball with the transmitters inside it. The range of the device needs to be reasonable, preferably between 10 and 200 yards. The
screen on the device will need to be accurate and give the proper location of the ball. The arrow indicator needs to point in the proper direction. If the device were accidentally dropped, then it should not shatter into pieces, and should properly locate the golf ball. The final results will also need to be inexpensive to manufacture. Table 3 shows the criteria for the prototypes, but there is no data to be collected yet.

Table 3. The matrices of location devices that use radio transmission, GPS, or a combination of both.

<table>
<thead>
<tr>
<th>Location Device Matrices</th>
<th>Max Points</th>
<th>Design 1 Radio Transmission and GPS</th>
<th>Design 2 Radio Transmission</th>
<th>Design 3 GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Locates the ball precisely</td>
<td>10</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>2. Can still point in the right direction, even when turned</td>
<td>9</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>3. Durable</td>
<td>8</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>4. Can sync to other balls</td>
<td>7</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>5. Aesthetically pleasing</td>
<td>5</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>6. Low cost/effort</td>
<td>5</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>44</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>100%</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

Most of the golf balls were tested for their durability. The balls were hit from exactly one meter away from a vertical blue tarp, where their forward progress was stopped. After ten trials for each ball, the results were recorded in Table 4.
Table 4. The balls were tested for their durability.

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Untampered Ball</th>
<th>Design 1 Liquid Metal</th>
<th>Design 2 Super Glue</th>
<th>Design 3 0.35 cm radius hole</th>
<th>Design 4 0.65 cm radius hole</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>X</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>3</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>4</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>5</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>6</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>8</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>9</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>10</td>
<td>P</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

- P – Pass, or did not break apart
- X – Failed, or fell apart during trial
- __–No data available
Data Analysis and Discussion

As a result from the data in Table 4, golf balls with holes drilled to the core will be the ideal solution to get the chip into the ball. The superglue ball broke apart on the first stroke, eliminating that possible solution. The smaller hole will be the least noticeable, but if the chip is too big to fit inside it, then it will not work. The larger hole can fit the chip, but will require more time and effort to seal.

There are many possible sources of error. If the balls were not filled with proper materials, the chip inside could break. If the filling materials caused the ball to have a different mass, density, or volume than it originally did, there could be an overall effect on gameplay. There are many different brands of golf balls. If one of the older styles were used that contained a rubber ball inside the core, then the chip could break more easily.

If the location device could not be synced to the golf ball, and Bluetooth was not working properly, then the receiver would be pointless. The coordinates that the device receives could be wrong, and then the screen could point in the opposite direction of the ball. If the device were dropped, then the receiving chip inside could become separated from the wires, and the device would not work.

The amount of g-force calculated could be off a little, so if it were slightly greater than it was actually, then there could be potential danger for the chip.
Conclusion

There was insufficient amount of data to reach a conclusion.
Literature Cited


Quantum dots - what are quantum dots, why are they important and what applications are they used in? (2005, August 25). Retrieved from http://www.azonano.com/


