Measuring Accuracy in Gateball

Please note. This article has been adapted for GB, with the permission of the author, from "Measuring Accuracy in Croquet to be found at: http://www.oxfordcroquet.com/tech/tymms/index.asp

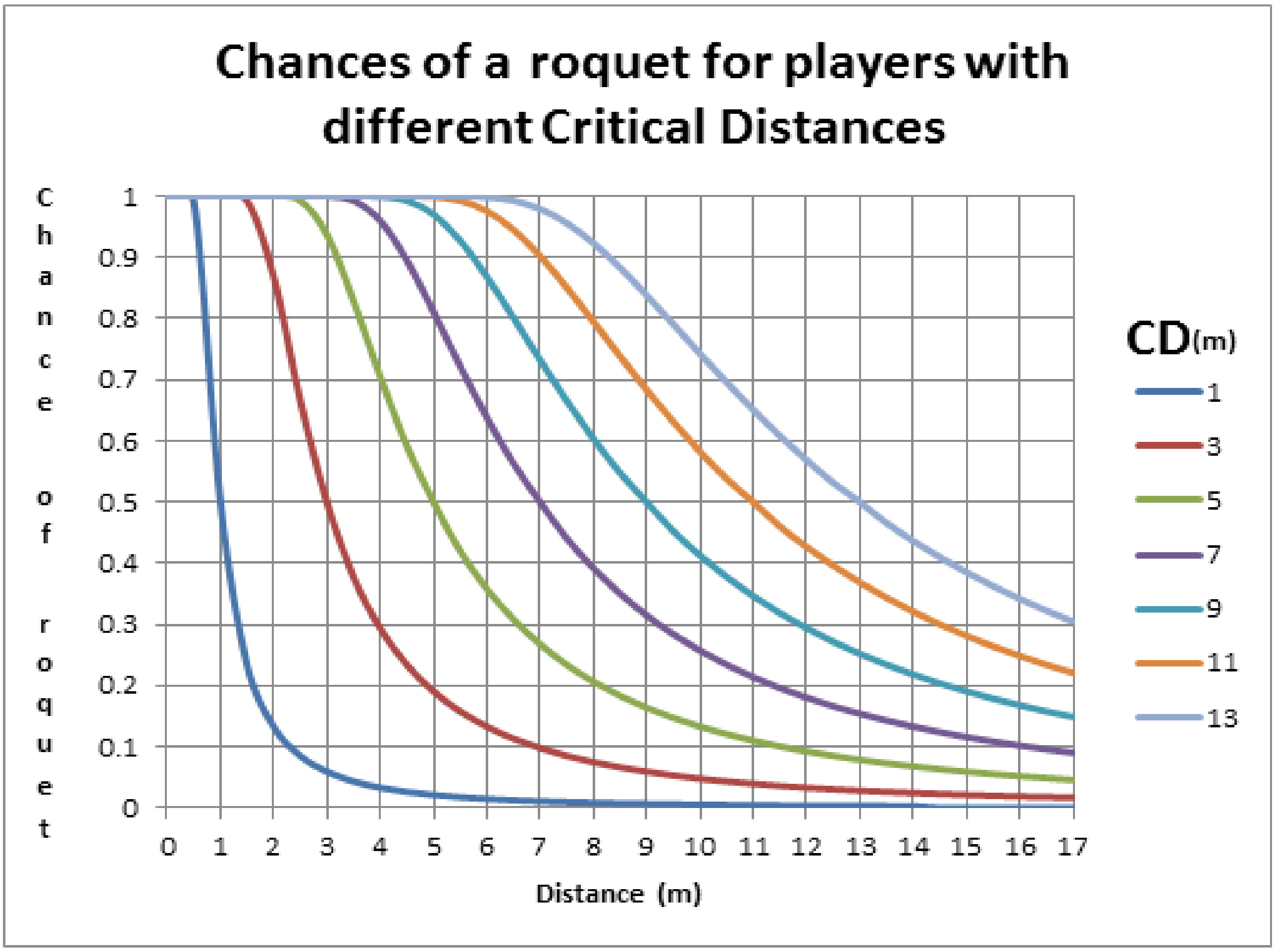
99% of the wording is that of the original author. Gateball appropriate terminology has been substituted and measurements adjusted to be gateball appropriate.

How accurate are you on the gateball court? This short piece builds on the idea of Critical Distance and shows how a player can measure his or her accuracy.

Critical Distance: The distance at which a player would expect to hit 50% of touch attempts

Of course the Critical Distance (CD) does not only depend of the player' **accuracy** but also court characteristics come into play. We can expect that a player's Critical Distance will vary from day to day, according to mood and focus, but we will proceed assuming that it is possible to explore accuracy whilst acknowledging that other factors are there in the background.

The chart below shows how the chances of players of different Critical Distances vary according to the distance from the object ball.(for roquet, read touch)



To get to grips with the chart consider a player with a Critical Distance of 5m (the green curve). When the distance is 5m the chance of a touch is 0.5 (or 50:50, or 50%, or 1 in 2), corresponding to the definition of Critical Distance.

At a distance of 10m the chance for that player drops to 0.13 – an outside chance of a touch. At 3m the chance rises to 0.93 – an almost certain hit.

In order to establish your own Critical Distance it would be possible to start by hitting a lot of balls at another ball from a distance of several metres. However the object ball will keep moving, when you hit it, and the ball would have to be tediously replaced. An easier approach is to try to hit the goal pole. This is harder than hitting a ball because the goal pole is thinner. Hitting a goal pole at 1m is equivalent to making a touch at approximately 1.6m and this equivalence allows you to measure your Critical Distance fairly easily.

How to Find Your Critical Distance

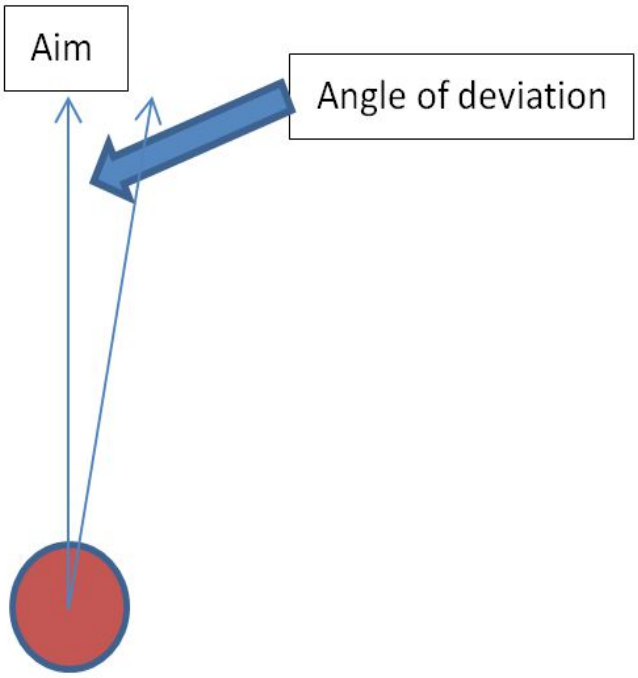
1. From your own experience estimate the distance, to the nearest metre, at which you have a 50:50 chance of hitting the goal pole .
2. Hit 25 balls from that distance and work out what proportion were successful.
3. Multiple the distance by 1.6 to get the equivalent distance for a touch
4. On the chart above mark a point corresponding to your proportion and distance. Read off your Critical Distance by seeing which of the coloured curves is closest. Of course you are unlikely to be exactly on one of the coloured lines but if there is one close then take that as your Critical Distance. If you are halfway between two lines horizontally then take your accuracy as an average of the lines to the right and left.

What Does Your Result Mean?

Your Critical Distance will be of some value when playing a game as it will help your captain figure out which shot is most favourable for you to take. If you estimate your opponent's critical distance it will be similarly useful for indicating their probability of successful shots.

Appendix: The Theory Behind the Charts

Aim: When a player tries to roquet he or she never does so perfectly; there is always some deviation from the ideal, however slight, and we can think of this as the angle shown below:



Normal distribution: When trying to hit one ball with another (making a touch) in addition to accuracy and concentration a host of other factors can influence the outcome. These include lawn imperfections caused by earthworms, weeds, grass type, the latest mowing, slopes, stray leaves and dew. Additionally the way that the mallet head hits the ball (angle and speed), the involuntary movements of the player during swings (breathing, heartbeat, unplanned jerks) and wind are all relevant, as is the player's concentration.

We can assume that the angle deviation does not depend on the distance of the ball from the other ball, so long as it is hit reasonably hard, but on the factors mentioned above. Because there are several independent causes of deviation we can assume that many attempts to make a roquet will result in a spread of shots that follow a normal distribution[1]: the closer the object ball the tighter the spread. This is shown below for a ball close to the player and some distance away.

The normal distribution has been extensively studied and we can draw on that knowledge base. Take a distance at which the player has a 50:50 chance of making a roquet. The normal distribution of shots is characterised by the Standard Deviation (SD) and it is convenient to assign it a SD of 1 at the 50:50 point. Sixty eight percent of shots will fall with one SD to the right or left of the centre and 18% of those will not make the roquet. Using the tables or an Excel spreadsheet, we can work out that 50% of the shots will come within 0.67 of a SD either side of the central point.

Now, for all other distances we know what the SD will be since it will be proportional to the distance from the player. We also know what width is needed to make a touch anything more would result in a miss. It is (0.67*2) and this stays constant whatever the distance. Using this constant figure and the SD for a particular distance we can work out, from tables, or using formulae in an Excel spreadsheet, what proportion of shots will successfully make a roquet.

How Many Shots are Needed in a Trial?

Consider the distribution of the number of successes of repeated trials of n shots.

The variance of a distribution is n * p(1 - p) where n is the number of trials and p is the probability of success[2].

We are interested in the SD (square root of the variance) for the CD when p is 0.5. This is

$$\sqrt{(n * 0.5(1 - 0.5))} = \sqrt{(0.25 * n)}$$

This expression give the SD of the number of shots and to convert it to a probability of making a roquet we need to divide by n giving $\sqrt{(0.25 / n)}$.

This give is the SD of chance of a roquet; the 68% Confidence Interval. It can be applied to chart for CDs. If we want to distinguish CDs of 1m apart then we need a 68% Confidence Interval of about 0.1. This implies 25 shots using the formula above.

Equating Touches and the Hitting of Goal Poles

A goal pole has a width of 20mm whereas the ball has a width of 75mm and so a ball which just would just hit a goal pole would touch another ball at 1.412 / (2*75)/(20+75) or 1.579 times the distance to the goal pole**.**

Provisos

1. A normal distribution is assumed but it would be interesting to gather evidence that to back up that assumption[3].
2. Hard hits tend to overcome lawn imperfections and longer shots may be hit harder. This is ignored here.

References

1. See for example **https://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/Chapter7.pdf**

2. **https://proofwiki.org/wiki/Variance_of_Binomial_Distribution**

3. It may be useful to look at calculation on other sports where it is often assumed that there is a normal distribution. For example for shooting rifles **http://www.the-long-family.com/group_size_analysis.htm** and for golf **http://www.stat.columbia.edu/~gelman/research/published/golf.pdf** [Archive copy]

4. For detail see **http://www.insearchoftheperfectmallet.com/miss.htm**