A pullometer - Seeing is believing

Good bell control depends critically on feeling what the bell is doing and varying the force applied to the moving rope in a timely, sensitive and accurate way. It is all too easy for an inexperienced ringer to apply too much force or too little, for too long or too short a time, or at the wrong time. This leads to less accurate bell control, and invariably to applying more force subsequently by way of correction.

Anyone who teaches ringers will have seen these problems many times, but how can we best help pupils to overcome them? We can give feedback: ‘Don’t pull so hard’, ‘Let the bell rise before you start pulling down’, ‘Follow through’, ‘Pull more at back than hand’ (or vice versa), ‘Don’t check so hard’, and so on. We know what we mean, and the pupil (usually) knows what the words mean, but how can we communicate what ‘too hard’ or ‘too soon’ feels like? The pupil is probably applying the force that feels right to him or her. What we can see as too much force, our pupil might see as necessary, because for example pulling any less results in the bell dropping.

We may know that it drops because in the eagerness to start pulling the arms are tightened before the bell reaches the top of the stroke, which prevents it going far enough, but it probably doesn’t feel like that to the pupil on the end of the rope. As for pulling earlier or later, we are talking about subtleties of a small fraction of a second whereas our pupil is probably just pulling whenever the rope seems to be there to be pulled.

Many ringers do manage to translate what we tell them into what they feel, and to develop efficient and effective bell control, but many don’t. Some may eventually manage to work it out for themselves when the penny suddenly drops but others may just give up trying and keep doing what they are already doing, and what for them seems to work. If they manage to become useful ringers it will be by developing strategies to cope with ringing inefficiently – strategies that normally rely on ringing a familiar bell that’s not too heavy, too light or too difficult.

Given the importance of a delicate touch, of being able to feel what the bell is doing, and of learning to apply the right force at the right time, wouldn’t it be lovely if we could show our pupils what forces they are really applying to the rope, in the same way that we can show them what they really do with their hands, arms and fingers between backstroke and handstroke using video, and we can let them review their striking after ringing with a simulator? That’s where the pullometer comes in.

The story so far

A pullometer doesn’t exist yet but people have been talking about it for decades. In the early ’90s I thought about the best place to measure the force. Between the garter hole and spokes would be no good because friction around the wheel would shield the sensor from much of the force applied to the rope (the capstan effect) so the ideal would be a device just above the sally that could measure the strain on the rope. But that would be difficult to engineer. The sensor would have to be slim and light so as not to affect rope handling, and it would need reliable wireless communication to get the data from it. I thought that developing such a high-tech gadget might appeal to a researcher in a university engineering department, so I wrote a specification and tried to generate some interest but with no success.

In the mid ’90s I mentioned the pullometer on *ChangeRingers* and Roger Bailey suggested standing on bathroom scales while ringing, because the ringer’s apparent weight would be reduced by pulling on the rope. I tried the idea at our next practice. The dial spun wildly back and forth all the time – obviously the scales were designed for measuring steady weights not rapidly varying forces. But even then we could see a significant difference between an experienced ringer (for whom the dial swung by a stone or two) and some less experienced ringers (for whom it swung right off the scale). Clearly there was a significant difference, and an instrument optimised to to cope with rapidly fluctuating force ought to be able to measure and display it.

Neil Donovan pointed out that the inertial effects of moving arms and/or body up and down while ringing will also register as changes of weight. He measured the force of someone standing on a force plate while moving arms up and down as if ringing, which gave peak excursions of about ±3% of the person’s weight. That would need to be taken into account but it didn’t seem large enough to render the approach impossible. In fact when the rope is taut (the main period of interest) the ringer’s hands move with the rope regardless of whether a lot or a little force is applied. That constraint wouldn’t apply while the rope is slack, where arm movement could vary more between individuals, so it would affect the measurement but it might also help to highlight non-standard arm actions.

After the bathroom scales experiment I decided to develop a pullometer. I started by gutting some old scales and replacing the dial with a potentiometer. But then the project stalled and after more than 20 years I realised I would never get round to completing it. I decided that if I couldn’t develop a pullometer then I would issue a challenge to encourage someone else to do so.

I discussed the terms of the challenge with a couple of people in 2014 and discovered to my surprise that Richard Johnston was already working on a pullometer. His approach was to measure the position of the wheel continuously and from that to derive the acceleration of the bell, and hence the force acting on it. The bell would have to be calibrated by letting it swing with no force on the rope to determine the base movement, against which the actual movement could be compared to detect the effect of the force applied by the ringer. He was using an optical sensor (a bit like a normal simulator but with several lasers instead of an LED in order to achieve the necessary resolution and accuracy) and instead of a single reflector that produces one pulse on each rotation, he had a strip with light/dark pattern around the whole wheel rim to give a continuous train of pulses.

Richard made significant progress but eventually concluded that he too was unlikely to be able to finish the project, though he would be happy to pass on what he had learned. So I decided to go ahead and issue the challenge, but between writing the first draft of this article and publishing it, yet more work came to light.

Ian McCullouch has been using solid state sensors and a micro-controller to detect the movement of the bell. He shared some of his results and discussed some significant problems that are still to be resolved. During the discussion it emerged that the bathroom scales concept wasn’t dead either – Stuart Flockton had done experiments a while ago using a Wii Board to measure force as variation in the ringer’s weight while ringing. Nor has the idea of directly measuring the rope tension died. Richard Johnston reported John Horrocks’ suggestion of doing it the same way the paper industry measures the movement of paper through machines. The rope would be made to run between three rollers, slightly offset so that the lateral force on the middle one depended on the tension in the rope.

In summary, there are several ways the force on a bell could be measured, and they all have pros and cons. Several people have worked on the problem over the years and some still are. Clearly there are people with the ideas and skills needed to tackle these problems. But no one has yet solved them all, and no one has yet produced a practical pullometer. We don’t know how difficult it will be to resolve the outstanding questions or which approach will eventually succeed, but it is likely to take considerable effort, which for most people will have to compete with the pressures of a ‘day job’.

The challenge

So back to where I was two years ago, I would like to offer an incentive to help someone, or maybe several people in collaboration, to make the effort and to succeed. I am issuing a challenge to develop a pullometer, and following the tradition of engineering grand challenges there will be cash prizes for the successful person or team. The prizes aren’t on the same scale as the Kremer Prize for man-powered flight but I hope they will still provide a useful stimulus. The challenge is in two parts – feasibility and ‘marketability’.

The feasibility stage is intended to demonstrate a usable tool, ie one with which an instructor could show a pupil the force (time profile and amount) that he or she was applying to the rope while ringing, in a way that could help to illustrate common handling traits, and that could allow the pupil to see whether he/she was improving with practice by comparing successive measurements.

The ‘marketability’ stage is intended to demonstrate that the approach can be replicated in a form that will permit uptake in reasonable numbers. ie that it is not so expensive, or difficult to acquire and install, that it would prevent a reasonably keen band in a typical tower from being able to obtain one and use it.

Although the background above has described some particular approaches to measuring the force, there is no limit on the solution or the technology to be adopted. The only criteria are that the resultant device works and that it is practical, usable and affordable.

1 Demonstrate feasibility – Build a working pullometer that meets the following requirements:

a) It can be installed for use with a normal tower bell.
b) It doesn't have a significant effect on the bell's normal handling.
c) It can show a graphical display versus time of the force that a ringer applies to the bell.
d) Its display can be selected to show either a single trace extending over many strokes, or successive strokes (whole pull or half pull) superimposed.
e) The display scale can be adjusted (manually or automatically) to show features of interest.
f) It can store multiple force recordings and recall them for display.
g) It can show two separate recordings together for comparison.

2 Demonstrate 'marketability' – Show that the pullometer design meets the following requirements:

a) It can be acquired at modest cost (target less than £100). (Components such as old computers that are widely available at no cost will not be included in the total.)
b) The on-bell components can be easily installed on a designated bell (target under 20 minutes).
c) Components in the bell chamber can be installed so that they are not vulnerable to damage when people walk around the frame and climb in and out of pits to perform routine maintenance or silence clappers.
d) Components in the ringing room that may be vulnerable to theft can easily be removed for safe storage and quickly set up again when needed. (It is assumed that the bell chamber is locked and secure so equipment there can remain in situ.)
e) There is a sustainable source of supply, ie one or other of the following applies:
   (i) The design is in the public domain, uses commercially available components and can be made using manufacturing techniques available to a competent amateur. Or ...
   (ii) If the developer is a sole supplier then there is evidence of capacity and willingness to supply a reasonable demand, and a credible assurance that in the event of not being able to supply the demand then condition (i) above will be met.

Awards

Solutions will be assessed against the above criteria, with the following awards offered:

- £500 to the first person or team to demonstrate feasibility (as defined above)
- An additional £250 if feasibility is demonstrated before the end of 2017
- An additional £500 to the first person or team to demonstrate 'marketability' (as defined above)
- An additional £250 if 'marketability' is demonstrated before the end of June 2018

In the event of more than one solution being offered at more or less the same time (say within one month) awards will be made on the basis of the comparative merits of the competing solutions.

For the marketability awards, a pre-assembled product costing £x will be rated as having a lower acquisition cost than a product requiring DIY assembly of components costing £x.

Where a target measure has been set (installation time or acquisition cost), discretion may be applied for a 'near miss'.

To discuss any aspect of this challenge, please contact me at: pullometer@jaharrison.me.uk. To apply for one of the awards and arrange an assessment of your pullometer, please contact me at the same address.