Improving the robustness of mobile health trials through online false discovery rate control

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With the widespread use of smartphones and wearable devices, mobile health (mHealth) technologies are increasingly being employed to deliver personalised and real-time health interventions. For example, data from activity trackers can be used to suggest physical activities which are tailored to the user’s past history and current environment. By allowing truly personalised interventions, mHealth can lead to immediate health benefits at the individual level.

A key barrier to the use of mHealth in practice is the lack of methodology to develop and validate the proposed interventions. Recently, a novel “micro-randomised” trial design has been proposed [1, 2], where treatments or interventions are sequentially randomised, so that each trial participant may be randomised hundreds or even thousands of times. These trials allow the real-time optimisation of the interventions given an individual’s past responses, through the use of adaptive randomisation that increases the probability of assignment to the best-performing treatments.

In a micro-randomized trial, each decision point (i.e. where the next intervention to give a participant is decided) can be viewed as an opportunity to perform formal hypothesis tests to determine whether an intervention is better than the alternatives. This allows interventions to be dropped from the trial for futility. Given the large number of tests that can be carried out, as well as the use of continuous monitoring of the intervention (allowing the possibility of making a decision earlier or later than originally planned), there is a high chance of making a false discovery – that is, erroneously declaring that an intervention is superior.

Hence there is a need to ensure that the false discovery rate is controlled in this micro-randomised trial setting. Recent methodological developments in online hypothesis testing, where hypotheses arrive sequentially in a stream, offer a promising starting point. In a recent paper [3], Yang et al. showed how to use online FDR control methodology in a related trial setting where multiple treatment arms are tested against a common control. The aim of this internship project is to adapt and extend this framework so that it can be applied to micro-randomised trials.

Depending on the interests of the intern, the project would cover some of the following areas:

- Developing a framework for multiple hypothesis testing in micro-randomised trials with continuous monitoring
- Investigating through simulation the false discovery rate and power achieved in realistic micro-randomised trial settings
- Extending the framework in [3] so that it is valid when:
  - Adaptive randomisation schemes are used
  - The p-values are correlated
  - The same hypothesis is tested repeatedly

The methodology developed in this project would allow robust testing in micro-randomised trials, with guaranteed FDR control while still maintaining high power and flexibility in monitoring.
References

