UK Biobank wrist-worn accelerometer data collection 2013-2015:
Differences between two enclosures for Axivity AX3 sensors

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During the 2013-2015 UK Biobank data collection, we started with a set of Axivity AX3 devices in an original enclosure and then moved to a newer batch of devices in a different enclosure (see figure 1). This document explains the relatively subtle differences between both batch of devices.

Figure 1 | Picture of first and second generations of Axivity AX3 enclosures used in UK Biobank (2013-2015). The turquoise blue outer case (here, without strap) shows the first-generation enclosure of the inner puck (yellow, faintly visible inside), while the black puck with silicone band shows the second-generation enclosure.

Differences in device orientation between enclosures

The inner, sensing device "puck" is the same throughout, and the natural "top" is the LED side (denoted by the blu-tac blob in the photos) and positive-Z axis – the axes have always been the same when orientated with the small "locator arrow": see https://github.com/digitalinteraction/openmovement/blob/master/Docs/ax3/axes.svg

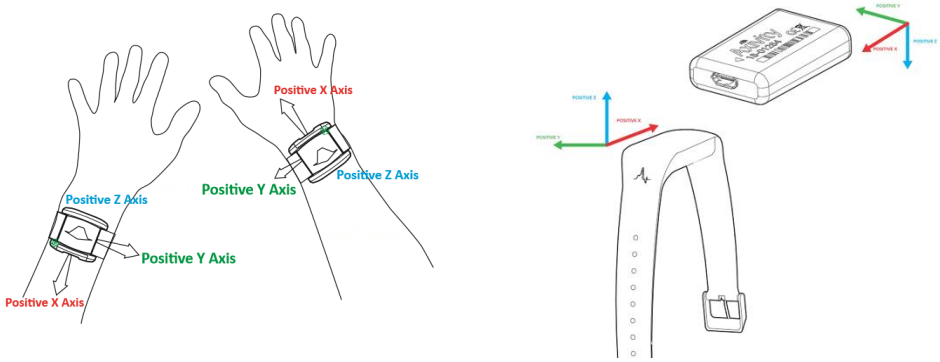

Figure 2 | Orientation of first and second generations of Axivity AX3 enclosures used in UK Biobank (2013-2015). The left-hand panel shows the first-generation while the right hand panel shows the second-generation enclosure.

The PCB board is always placed in a waterproof puck. The original turquoise-blue housing is an outer shell for the puck. This original housing and strap arrangement had the tapered/arrow end (positive-X) pointing up the left arm, or down the right arm (if worn correctly). The newer outer silicone strap re-orientated the (now, easily removable) puck to make it more comfortable; with the tapered/arrow end pointing at 12 o'clock if it was a watch; so positive-Y up the left arm, or down the right arm.

Many of the original Biobank enclosures eventually had failed corner linkage to the strap and were "refurbished": the inner puck removed and the whole thing re-housed in the newer silicone straps – thus, some devices will have a different orientation for later recordings, but these were given a new numerical identifier.

Considerations when analysing UK Biobank accelerometer data

It is possible that participants moved devices from one arm to another during the measurement or removed and re-orientated the puck. Wearing the device on one side of the body or the other will, because of the bilateral symmetry, necessarily change which axes/directions experience the activities of daily living. However, the axes in the plane of the device (X/Y) perform similarly, and the effect of flipping the device around will be to simply swap/invert these axes. To avoid the issue of orientation altogether, it will usually be most pragmatic to just consider the "vector length" as the orientation will then not make a difference.

For the small number of researchers who need to access timestamp from the raw CWA file, there is one extra consideration. As background, one sample in each "sector" of data (typically 120 samples for the Biobank configuration), is assigned a timestamp. The very first few devices used for some pilot data collection used an older version of the firmware that couldn't determine this timestamp to a fraction of a second, but rather gave the nearest sample a timestamp (approx. 10 msec resolution as they were used at 100Hz), whereas the later versions could determine a fractional timestamp. To be backwards compatible with older readers, they adjusted which sample index it was assigned to, to be the one nearest the whole second value – newer readers see the fractional value and can undo this backwards-compatible adjustment. The net result is that individual timestamps will have slightly different properties on the very oldest firmware to later ones. This slight difference is highly unlikely to affect any epoch-level calculations.

Considerations when comparing UK Biobank accelerometer data to current Axivity devices

The current generation of AX3 devices, not used in Biobank, has the USB connector relocated to the opposite end. However, they are otherwise identical and all of the major components are in exactly the same locations as before. As a result, the connector should not be used as an indication of orientation but, rather, only the small "locator arrow" on the tapered end, as this external marker has always remained the same position.

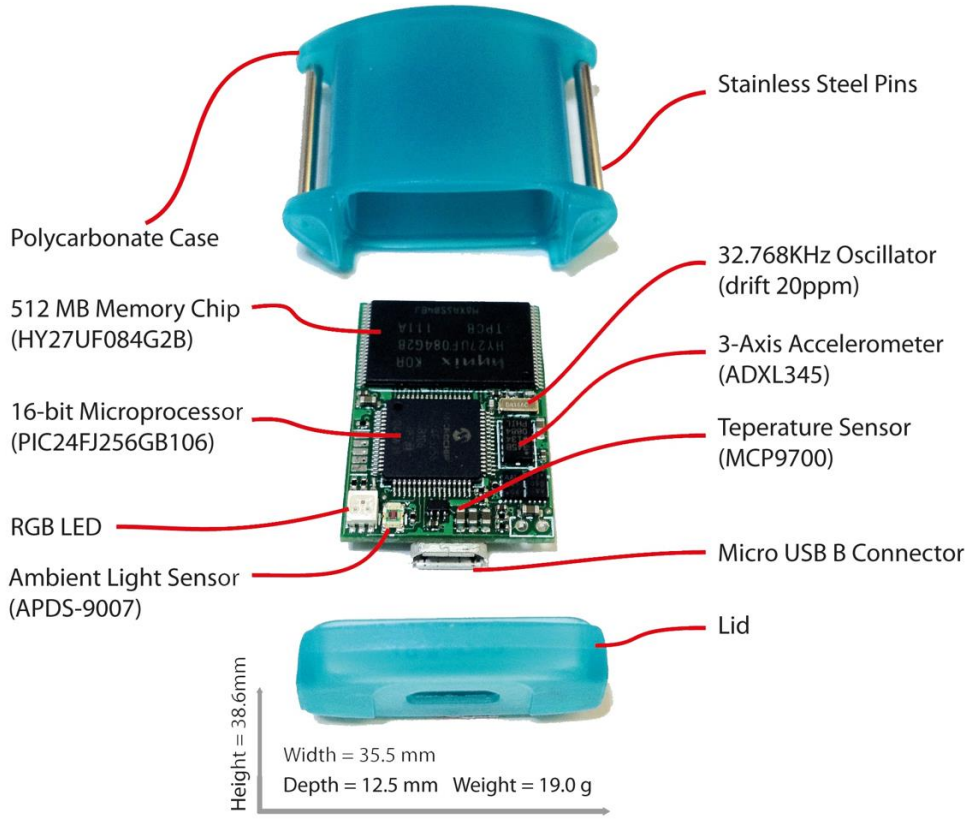

Figure 3 | Design of first generation Axivity AX3 enclosure used in UK Biobank (2013-2015) – inner puck not shown.