PROCEEDINGS

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MEASURING IMPACTS AND INFORMING MODELLING PROCESSES

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Primarily using rugby union situations as case study examples for the practical demonstration, the initial part of the session will discuss both familiar and emerging techniques to measure the biomechanics of sport impact situations. We will cover some of the issues that need to be accounted for to acquire robust data in such complex environments, and we will discuss how experimental measures can be either used in their own right to develop knowledge of impact biomechanics or can provide data to input a modelling pipeline and for model validation purposes.

KEY WORDS: impact, synchronisation, wearable sensors, calibration, model evaluation.

Obtaining experimental data from sport impact situations is challenging. In many ways the techniques to be employed are the same as more ‘standard’ situations but the task is made more challenging because the movements are faster, the forces are higher, attaching sensors may be more difficult, the data conditioning processes more volatile, and the actions may be more difficult to perform in a laboratory setting. The movement setting can be made more ecologically valid by conducting ‘field-based’ analyses but this may exacerbate the technical challenges of acquiring robust biomechanical data.

As with most biomechanics applications, the collection of experimental data for studying sport impact situations is a core element. The experimental measures can be used in their own right to derive information on the biomechanics of the movements being tested and they also address a key component of any modelling pipeline, forming the input data streams and datasets by which to perform model evaluations.

When analysing sport impacts, many of the established measurement techniques with which the biomechanics community will be familiar can be employed. These include motion capture, force plates, video analysis, and EMG. In field-based testing it may be necessary to consider alternative routes for obtaining force data where force platforms cannot be used. For this, integration of load cells into sports equipment is one route to achieving information about external loading (Preatoni et al., 2012; Preatoni et al., 2015)

In some sport impact situations external loading on the human body may arise from sources other than ground reaction forces, for example in player-on-player collisions. In these situations traditional force measurement is not possible and alternative means are required. The emergence of wearable sensor technology has provided opportunities for such measurement, in the form of pressure sensors, accelerometers, and inertial measurement units (IMUs). Perhaps none of these methods provide the ‘gold standard’ result we come to expect from force platforms and so it may be advisable to obtain a number of data streams from different technologies in order to build up an overall picture of the impact situation (e.g. Cazzola et al 2015, Figure 1). In using multiple wearable sensors as surrogates for force measures then appropriate calibration is required (Cazzola et al, 2013) and attention needs to be paid to ensure all acquisition devices are appropriately synchronised (Figure 1d)

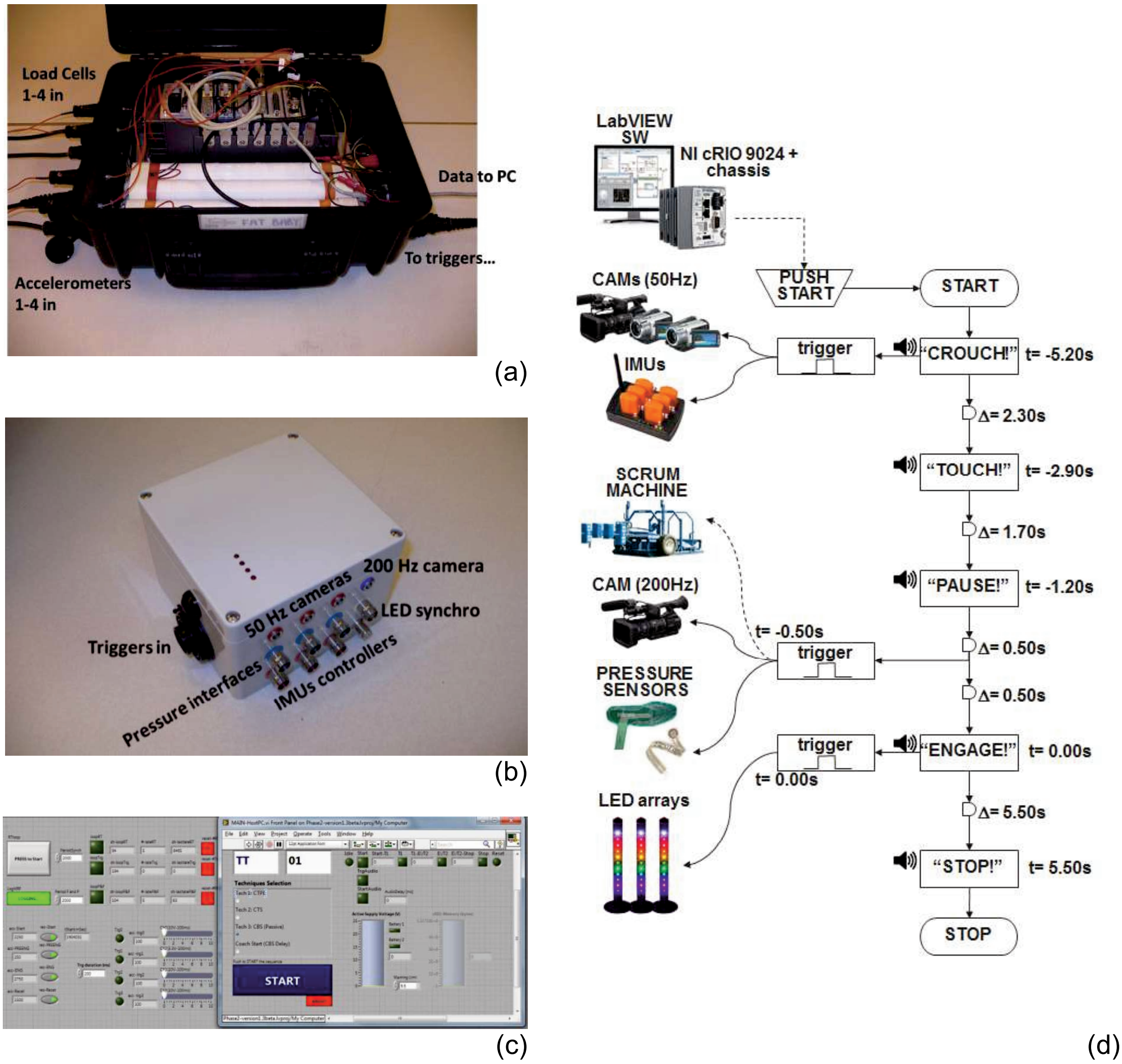

Figure 1. An example of an experimental set-up to acquire multiple data streams to analyse the biomechanics of rugby scrummaging: a) NI controller and acquisition device; b) bespoke triggering box; c) Labview interface to control data acquisition; d) timeline of triggering to synchronise data streams with the movement events..

In measuring impact situations it is particularly important to be cognisant of the measurement capacity (dynamic ranges, sampling rates, measurement resolution) of the equipment being used to make sure it is sufficient to track the evolving mechanics of the impact and to develop a grasp of the smallest effects that can be detected. It may also be necessary to consider some non-standard data conditioning techniques when processing raw data. For example, we have had some success in utilising adaptive filters (Erer, 2007) for smoothing force and motion data in signals involving impacts and time-varying frequency characteristics.

Experimental data also plays a fundamental role when incorporating musculoskeletal models into sport impact research. Experimental data informs model parameters (inertia data, muscle force characteristics), provides input data (ground reaction forces, motion data) and initial conditions (model pose) to model simulations, and supplies data on which to validate model behaviour during matching simulations. Depending on the construction of the model and the type of analysis being performed, experimental datasets which can be used as part of a model validation package include joint kinematics, ground reaction forces, EMG, and joint moments from inverse dynamics (e.g. Hamner et al., 2010).

In this first main part of the workshop we will demonstrate the use and output of selected wearable sensor technologies which can be used to study sport impact situations in a field-based (mobile laboratory) setting, using the example of rugby contacts situations (scrummaging and tackling). We will briefly cover some of the main factors to consider when acquiring experimental data from sport impacts and bridge into the modelling section of the workshop by demonstrating and discussing how data streams can be utilised to provide input and validation data for modelling purposes.

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