碰撞假人传感器的最近进展

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摘要

为了满足生物逼真性和测量能力的要求，碰撞试验假人变得越来越复杂。假人的反应参数（如线变形、角变形、线加速度、角加速度、力和力矩等）和他们的组合通常用作为身体各部位受伤的指标。在车辆碰撞试验中，传感器的信号被广泛用来评价身体受伤的可能性和汽车的安全性。

线性变形量是胸部受伤的主要指标。在混 III 假人系列中，只有一个传感器测量胸部一点的变形。因此，如果在碰撞中，胸部变形不均匀，胸部的最大变形就不一定能检测到。最近成为美国 NHTSA 标准的 SID-2s 亦存在同样的缺陷。如果一只安装在座凳的侧面气囊将假人的胸部往侧前方推，电位计所测量出来的肋骨侧面变形将会较少。这些假人和传感器的缺陷可能会被一些汽车厂家利用，以减少肋骨侧面变形量和提高汽车的“安全性”。这种汽车设计方法可能对碰撞假人和车辆安全性的星级有帮助，但是不一定能增加对真人的保护。所以，多点测量是最近假人变形测量传感器的研究重点。本文将介绍一些多点测量的方法。

碰撞假人配备越来越多的力传感器。例如，在 80 年代的混 III 50 假人的 NHTSA 图纸包中，只指定了两个力传感器（6 轴上颈和单轴大腿），而最近的 SID-2s 假人有 9 个力传感器。除了 NHTSA 指定的力传感器之外，许多假人的部件都可以设计成为力传感器。例如，现在能够安装在混 III 50 假人的力传感器超过 30 种。工程师可以通过这些力传感器信号来分析假人内部和外部的负载路径，因而设计出安全性较高的汽车安全系统。本文将介绍力传感器的原理和标定方法。

越来越多的汽车安全工程师开始注意到假人各部件（如头、身躯、手、腿、脚等）的运动学(3 维的位移和旋转)。在汽车碰撞试验中，由于气囊和车辆结构障碍了视线，通过高速影像机也很难看清楚头部和脚部的运动。如果能够测量这些部位的 3 维运动，对于分析脖子和小腿的受伤将会有帮助。本文也将介绍测量 3 维运动的方法。

美国 NHTSA 的图纸包规定了传感器的外形尺寸和重量。在 2001 年，SAE 发表了一份假人传感器性能要求文件 （J2570）。J2570 规定了用于假人的传感器（如位移、加速度、力和力矩）的规格性能（如非线性、频率响应等）。最近的争论是有阻尼加速度传感器能不能替代无阻尼加速度传感器。本文将对这些标准作简单介绍。

Recent Development in Crash Test Dummy Sensors

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ABSTRACT

Crash test dummies have become more and more complex in order to meet the requirements for Biofidelity and measurement capabilities. The physical response parameters (linear and angular deflection, angular and linear acceleration, force and moment) and their combination are typically used as injury

indicators. Sensors have been widely used to provide critical data in evaluating potential injuries in various body regions in a vehicle crash.

Linear deflection has been historically to be considered as a key indicator of chest injury. In the Hybrid III dummy family, the chest deflection is measured at one point. Therefore, the maximum chest deflection cannot be detected if the chest deformation is non-uniform. Similar deficiency can be found in the SID-2s dummy. If a seat mounted side airbag pushes the SID-2s rib cage forward instead of laterally, the "rib deflection" as measured by the linear potentiometer can be very small since the potentiometer only measures the lateral deflection. It is possible for an OEM to enhance the "safety rating" of their vehicle by utilizing the deficiency in the dummy and sensor. However, this design method does not necessarily help human drivers in the field during a crash. Some of the recent attempts to address this issue will be discussed in this paper.

More and more load cells are packaged into a dummy. For example, in the initial NHTSA's drawing package of the Hybrid III 50th dummy, there were only two load cells – upper neck and femur. In the recent release drawing package for SID-2s dummy, there are nine load cells. Many custom load cells are also required to clarify internal and external load paths in a dummy. Engineers can use these load cells to determine the exact loading conditions, and thus to find a countermeasure for enhancing the vehicle design. The principle of a load cell and the calibration method are to be demonstrated in this paper.

Understanding of the dummy kinematics (linear and angular motion of each body region) is also very helpful in analyzing the internal and external load paths within a dummy and also dummy-vehicle interaction. Angular sensors can be used to measure joint rotation. Angular velocity sensors may be used in the body regions that do not have a clear joint linkage (e.g. the head to the spine box).

The regulated dummy sensors are specified in the NHTSA's dummy drawing packages, which can be downloaded from NHTSA web site dms.dot.gov. In 2001, a SAE task group was commissioned to define a SAE standard on the transducer equivalence, SAE J2570 – "Performance Specifications for Anthropomorphic Test Device". The current debate is whether a damped accelerometer can be used to replace an undamped one on a vehicle certification test. The outline of this standard will be discussed in this paper.