A PROPOSED SIDE IMPACT ATD BIO-FIDELITY EVALUATION SCHEME USING CROSS-CORRELATION APPROACH

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ABSTRACT

ISO/TR9790 has been in existence for some years for evaluating the bio-fidelity of side impact ATD's (ISO/TR 9790, 1999). NHTSA recently generated a new method for creating bio-fidelity corridors. The method was different from the ISO method, by incorporating statistics and the time relationships into the evaluation equation and automating the process (Maltese et al. 2002). Although both the ISO and NHTSA methods exhibit a number of strengths, they also have weaknesses. This paper attempts to build on these two methods and develop an ATD assessment method which offers added objectivity and is based on a statistical process. Improvements were explored in several key areas to address the existing numeric issues (Hsu et al., 2005). This process bases itself on the statistical correlations between the post-mortem human subject (PMHS) data. Validation of the scheme is performed using PMHSs as "pseudo dummies". A simple formula is proposed for ranking the bio-fidelity of the dummy, resulting in a score from 0-10, with 10 being the best.

INTRODUCTION

Since the 1950's various mechanical human surrogates, or Anthropomorphic Test Devices (ATD), have been used for assessing the potential for injury in vehicle crash tests. These ATD crash test dummies have become more sophisticated, complex, and potentially more human-like through the years, but still provide only very limited estimations of what might occur in a real life crash. In order to improve this prediction, efforts have been made through the years to make the ATDs more bio-fidelic. However, an omni-directional dummy has not been developed. Instead, dummies have been created for each type of impact, resulting in a variety of different ATDs in frontal, side, and rear impacts. For some of these impact types, a whole family of ATD sizes has been developed.

Each of these ATDs has its own set of performance requirements, calibration procedures, and response corridors that have been developed in an attempt to make the dummy better mimic a human, as well as ensuring repeatability of responses. Many attempts have been made to determine the level of bio-fidelity. Tests have been performed using PMHSs to gather information on what injury response would be in certain loading situations. The difficulty however, lies in how to correlate the findings from these tests with those of the ATDs, i.e., determining how accurately an ATD crash test dummy response represents "real" human injury.

In 1989, the International Standards Organization (ISO) first published ISO/TR 9790, which defined a bio-fidelity evaluation approach for side impact dummies (Figure 1). Defining a method to standardize the determination of bio-fidelity was a big step forward. However, the actual method required some level of subjectivity and the resulting corridors were large, allowing the acceptability of a large amount of variation in the results.

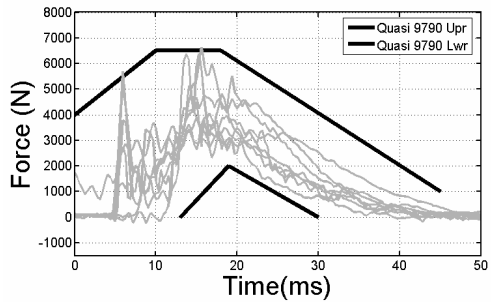


Figure 1. Typical ISO bio-fidelity corridor.

In an effort to reduce the subjectivity and improve upon the ISO method, Maltese et al., at the National Highway Traffic and Safety Administration (NHTSA), published a new method for creating bio-fidelity corridors. This method used a statistical cumulative variance approach to align the signals, which were then averaged. A corridor was then automatically created, with its boundaries defined as plus and minus one standard deviation from the mean of the aligned signals. Thus this created a tighter

corridor, which in general, better resembled the shape of the test data curves (Figure 2).

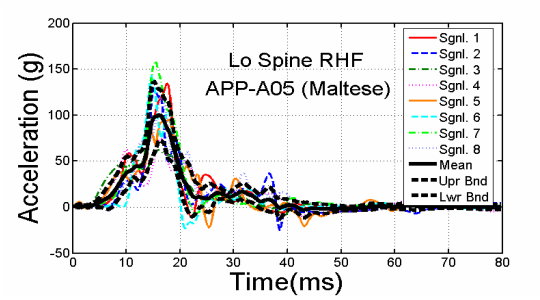


Figure 2. Typical Maltese bio-fidelity corridor.

Although this method appeared to remove some of the human intervention found in the ISO method, it too had shortcomings (Hsu et al. 2005). The selection of the standard signal with which to align the others, still involved some subjectivity. The method for aligning the curves involved variability in time shifting, which could destroy relative timing information and in some situations the resulting corridor lacked physical meaning.

This paper presents a statistical, correlation based method that builds upon the work incorporated into the ISO and Maltese methods. One notable difference in this new method is that it does not generate physical corridors. Instead it examines and compares the magnitude, shape, and phase relationships of the curves to determine the level of similarity. It then calculates a simple bio-fidelity score, based on these cross-correlation comparisons. This method avoids the issues caused by subjective evaluation, time shifting, and variable time history lengths. It is fully automatic and updatable. This bio-fidelity score should be more statistics based, straightforward, and representative of actual bio-fidelity than the existing methods.

CROSS-CORRELATION BASED APPROACH

As discussed, current dummy evaluation methods have areas that could be improved. In an earlier study (Hsu et al. 2005), several areas for improvement were identified. Among them, the use of a correlation method to better preserve the signal characteristics and to resolve issues resulting from time shifting, manual standard curve selection, and inconsistency in the integration time period. The proposed method aims at forming a more objective, scientific, statistically meaningful and easily applicable ATD assessment alternative.

Areas of Improvement

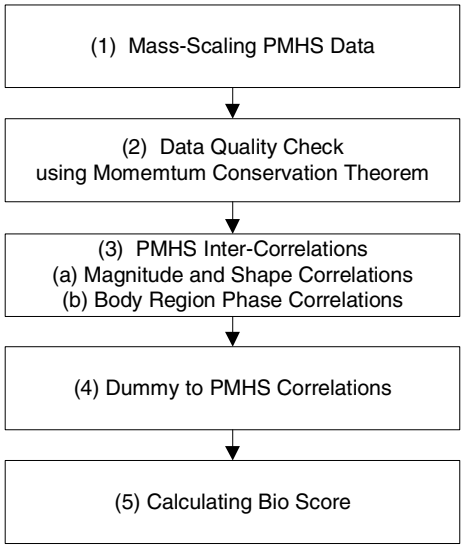
This approach attempts to address the following areas key to a broader scientific method in evaluating the side impact ATD:

- Incorporation of statistical correlations
- Reduction of manual intervention
- Incorporation of complete time history
- Reduction of numeric issues
- Automation of the process and improvement of process robustness

The approach proposed does not require a fixed set of PMHS data (one or greater is required). Rather, a continuously updatable set of PMHS data is used. The scheme does not shift the data as is done in Maltese's method. It is believed that the correlation method will take care of the relative timing information by using phase correlation coefficients. By eliminating time shifting, the potential destruction of relative timing information is avoided.

Steps

A flow chart of the proposed process is shown below.



The steps to obtain the biofidelic score of an ATD consist of mass-scaling the PMHS data, scrutinizing the data using the momentum conservation theorem, calculating the magnitude, shape, and phase correlations of the PMHSs and the dummy, comparing the correlations of the dummy to the averages of that of the PMHSs (magnitude and shape), obtaining the relative phase differences between different body regions of the dummy and of

each PMHS, and calculating the bio-fidelity score of the dummy using a multifactor based formula.

Data used in the study are from NHTSA's biomechanical research program portfolio on its public websites. Figure 3 shows a typical sled test set-up. Figures 4 and 5 show some typical signal traces for PMHSs and dummies in sled tests. The data was mass-scaled to account for the different sized PMHSs. Since no time shifting is performed, all of the relevant signal timings are preserved.

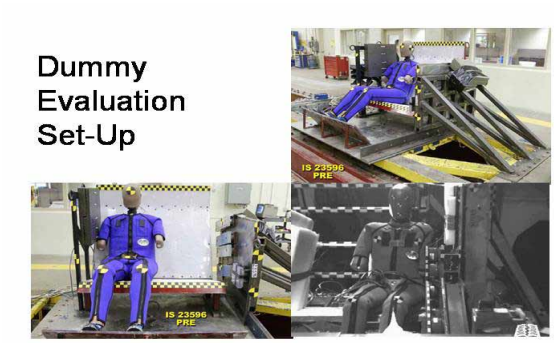


Figure 3. Typical set-up for NHTSA's biomechanical tests.

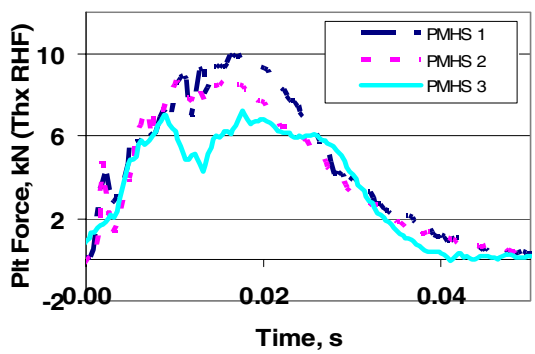


Figure 4. Typical PMHS test time histories.

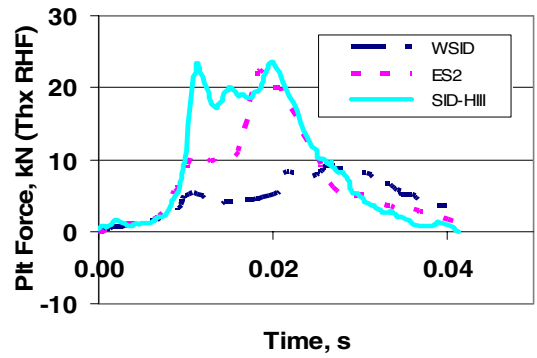


Figure 5. Typical dummy test time histories.

(1) Mass-Scaling PMHS Data

The PMHS data is mass-scaled using Eppinger's technique (Eppinger et al. 1984). The scaling process is described by Maltese (Maltese et al. 2002).

(2) Data Quality Check

Before the correlations are calculated, corrupted signals need to be identified and removed to ensure the quality of the process. ISO/TR9790 does this similarly by removing from the data sets the PMHSs which sustained severe rib fractures. In the approach herein, data are scrutinized using the momentum conservation theorem. The process is done to the force data, based on the theory that the summation of the force over time for a particular test condition should be relatively consistent from test to test. The same is true for the acceleration data, assuming equivalent masses can be considered constant and then applying Newton's theorem, ***F=m*a***. This way, the contamination due to instrumentation malfunction or improper calibration can be singled out easily. Since the energy inputs are the same for the group of PMHSs under the same test conditions, the integration of the response time histories from that group should yield the same value over time based on the momentum conservation theorem (Equation 1.):

$$m * V = \int F dt \qquad (1).$$

i.e., for a set test condition, the velocity and the integration of the force over time should yield the same results. Those PMHSs that deviate from the majority of the group when integrated indicate that they either have different momentum, incorrect set-ups, an error in the data acquisition process due to miscalibration, a bad connection, or a static interference issue. The signals whose integrations

deviate from the majority of the group are dropped. e.g., an arbitrary 20% has been chosen as the threshold for data elimination. Those having greater than 20% deviations from the group mean are considered to be outliers, or bad data. Only the data meeting the momentum conservation equation are used for the subsequent bio-fidelity evaluation. For the purpose of illustration, a set of thorax rigid plate high speed plate force signals is plotted in Figures 6 and 7. Five out of the six tests in the graph have similar momentum, while the one with the dashed line has distinctly different integration results. All data except that test are then used for the correlation analysis.

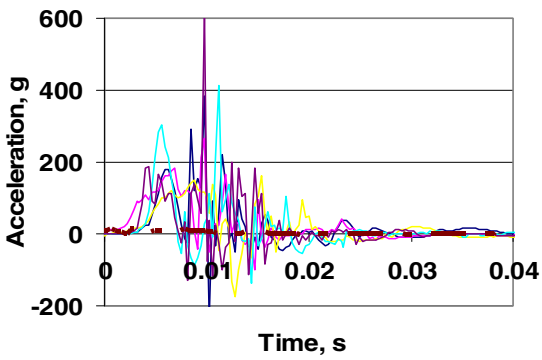


Figure 6. PMHS signals used for dummy evaluation before integration and drop of bad data.

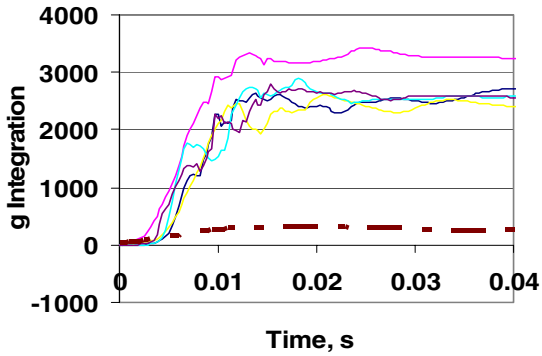


Figure 7. PMHS signals used for dummy evaluation after integration. The test with a dashed line is dropped as a result of failing the momentum conservation theorem.

(3) PMHS Inter-Correlations

After the clean-up process, the correlation baseline from the PMHSs can be established. The cross-correlations between the PMHSs themselves are calculated using the following methods. Three quantitative indicators are utilized (Figure 8). They are magnitude, shape, and phase correlations, as described by Xu (Xu 2000).

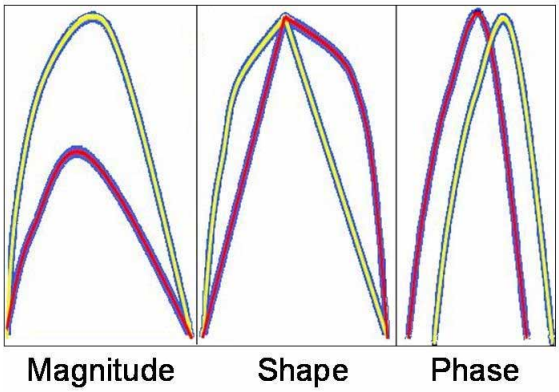


Figure 8. Schematic representation of three cross-correlation indicators.

(3a) Magnitude and Shape Correlations

Mathematically, the magnitude and shape correlations of the PMHSs are between 0 and 1, with one indicating that the two signals are identical (Figures 9 & 10).

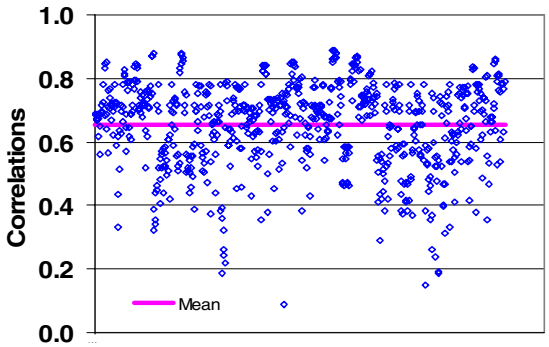


Figure 9. Typical scatter of magnitude cross-correlation coefficients of PMHS test data.

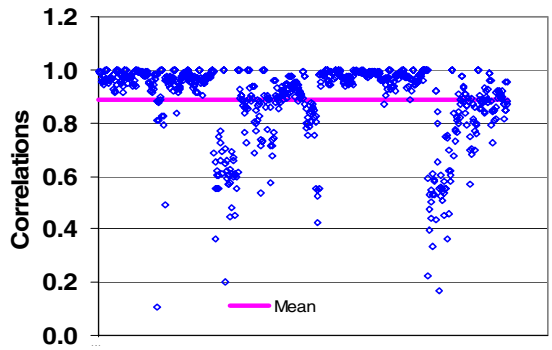


Figure 10. Typical scatter of shape cross-correlation coefficients of PMHS test data.

The correlations are calculated in the following way to achieve reasonable and balanced numeric results. First, the one to one correlations between every two PMHSs, including itself, are calculated.

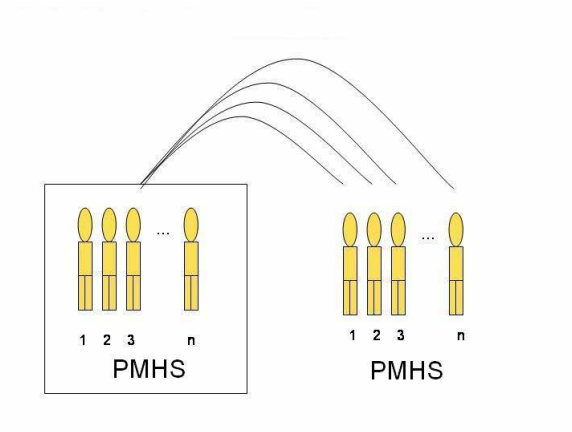


Figure 11. Magnitude and shape cross-correlation calculation.

Their sums are averaged. In averaging the sums, including or not including the auto-correlations (the cross-correlations of a PMHS with itself) yields slight differences in outcome, but is believed to be minimal (Figures 12 & 14).

Tables 1 and 2 show some correlation calculations from PMHS data in 9.8 mph tests using the PHF (Padded High speed Flat/no offset) test condition. The average of all PMHSs is shown in the top row, and the PMHS with the worst correlation is shown in the second row. As mentioned above, those time histories failing the momentum conservation guidelines are already excluded from the calculation.

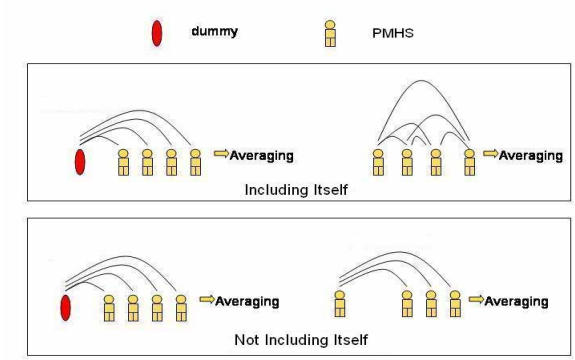


Figure 12. Two schemes for collective correlation calculations.

Table 1.
Example magnitude correlation results for three different body regions (not normalized)

BIO-FIDELITY BASED ON MAGNITUDE - PHF			
	Thorax	Abdomen	Pelvis
PMHS(ave)	0.8185	0.9164	0.8841
PMHS(wst)	0.7265	0.7104	0.8650
SID	0.2683	0.6232	0.5762
ES-2	0.5950	0.8160	0.7198
WSID	0.7212	0.7246	0.8729

(3b) Body Region Phase Correlations

While the time history magnitude and the time history shape correlations are based on a PMHS local body region, the phase relationships are compared between different anatomical regions (Figure 13). Phases between the different body regions of each PMHS are also averaged and the duration calculated. The reason for this is that it has been seen that the relative timing between body regions in a crash is critical for representing human body kinematics during an impact event.

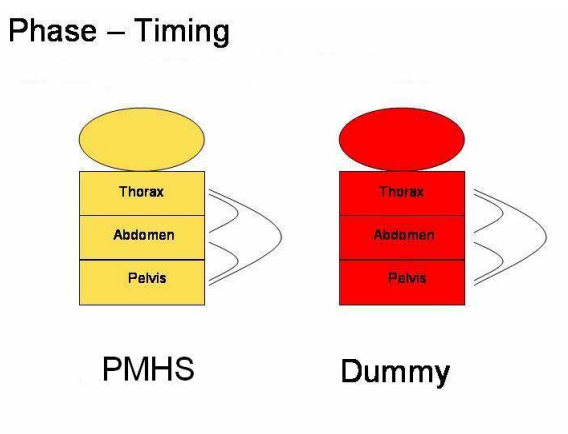


Figure 13. Schematic representation of phase correlation calculation.

(4) Dummy to PMHS Correlations

As the next step, a dummy's correlations to each and every PMHS are calculated similarly to the way the inter-PMHSs correlations are calculated. Some earlier/prototype test data for SID, ES-2 and WorldSID are used here as an example.

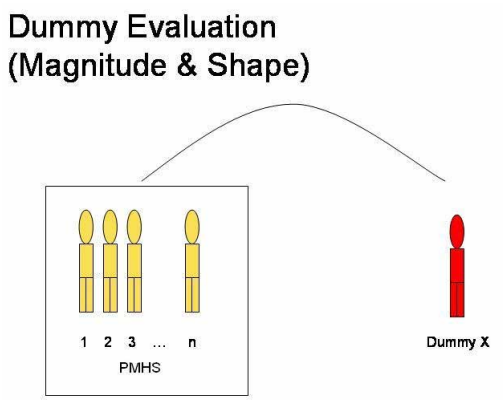


Figure 14. The dummy time history is checked against each PMHS time history in the process.

The average of the magnitude, shape and phase correlations of the dummy to each of the PMHSs is obtained. These results are shown in Tables 1, 2 and 3, in the bottom three rows.

To check the dummy's bio-fidelity, theoretically either the worst PMHS performer, the best PMHS performer or the average of a PMHS group can be used as the threshold. Which is more appropriate, or more truly reflects the dummy's bio-fidelity, is yet to be determined. Nevertheless, the procedures are the same for either method. Only the results from the averaged PMHSs are shown in Table 1. In the following discussion, the average PMHS method is used for the purpose of describing the process. If using the best or worst PMHS is deemed to be more appropriate, it can be easily implemented without the need to change the formula.

(5) Calculating the Bio Score

A few variations in the dummy evaluation scheme formulation can be used, as long as the main objective remains to effectively measure the closeness of the ATD's responses to those of the PMHSs. In the proposed approach, after the correlations of inter-PMHSs and between dummy and PMHSs are calculated, summed, and averaged, the ratios of the two averages are used for the bio-fidelity score calculations. Equation 2 is proposed for that purpose. In Equation 2, the scaling factor of 10 is used to yield a score of 0 to 10.

The magnitude and shape correlations are normalized by dividing the average PMHS to dummy correlation by the average PMHS to PMHS correlation (Table 2). For the phase correlation contribution, the coefficients are normalized according to Equations 5, 6 and 7. They represent results as a function of total duration, as well as the time lags between different body regions.

$$Bio\ Fidelity\ \ Score\ \ =\ \ [RMAG * RSHA * RPHA] * 10 \qquad (2).$$

where,

$$RMAG\ =\ Ratio\ of\ \ Average\ Magnitude\ \ Cross\ Correlations\ of\ Dummy\ to\ PMHS\ to\ that\ of\ \ PMHS\ to\ PMHS\ \ (1.0,\ \ if\ >1.0) \qquad (3).$$

$$RSHA = Ratio\ of\ Average\ Shape\ Cross\ Correlations\ of\ Dummy\ to\ PMHS\ to\ that\ of\ PMHS\ to\ PMHS \quad (1.0,\ if > 1.0) \qquad (4).$$

$$RPHA = Ratio\ of\ RPHA1\ of\ Dummy\ to\ PMHS\ to\ that\ of\ PMHS\ to\ PMHS \quad (1.0,\ if > 1.0) \qquad (5).$$

$$RPHA1 = \sum \frac{DURDIFF}{Duration} \qquad (6).$$

where,

$$DURDIFF = Duration - Absolute\ Phase\ Differences\ Between\ Body\ Regions \qquad (7).$$

Table 2.
Example magnitude correlation results for thorax (normalized)

MAGNITUDE - Thorax PHF		
		Normalized
PMHS(ave)	0.8185	
PMHS(wst)	0.7265	
SID	0.2683	0.3278
ES-2	0.5950	0.7269
WSID	0.7212	0.8811

All three key indicators are represented in the formula and given equal weights. The formulation of the equation yields a score of 10 when the subjects to be compared are identical and a score of 0 when they are statistically completely unrelated. The evaluation thus ties the closeness of the ATD impact response time history of a given anatomical structure to that of the impact response time history of the human surrogates using a numeric score defined as the bio-fidelity score. If the ATD's statistical relationships to the PMHSs are equal to or greater than those between the PMHSs, the ATD's bio-fidelity is considered to be excellent. If it is below the statistical relationships of the PMHSs then that is considered to have low bio-fidelity.

Example

The sled data for the PHF test condition (Padded, High speed /8.9 mph, Flat/no offset) from some earlier/prototype SID-3, ES-2, and WorldSID tests are used to show the process of the bio-fidelity evaluation scheme being proposed (Tables 3 and A1).

The magnitude and shape correlations of the dummy to the PMHSs are compared to the averages of the PMHSs by dividing the correlations of the dummy to the PMHSs by that of the PMHSs. In Table A1, R8C4 (Row 8 Column 4) divided by R5C4 results in R12C4, and R9C4 divided by R5C4 results in R13C4, etc. If the quotient is greater than one, one is used instead. The same is done with the shape correlations (row 12-14, column 6, etc.). The relative phase differences between different body regions of each PMHS are obtained (timing differences shown in ms in the example, row 5 col 8), as well as the duration of each signal (time between the first zero crossing before and after the peak time, row 5 col 9). Note that those results are yet to be updated with newly available SID-3, ES-2, and WorldSID data.

Table 3.
Example magnitude, shape, and phase correlation results for thorax (not normalized).

		Magnitude	Shape	Phase	Duration (period)
Thorax (Not Normalized)					
	PMHS(ave)	0.8185	0.9960	0.3189	53.75
	PMHS(wst)	0.7265	0.9920		
	SID	0.2683	0.9767	5.0900	
	ES-2	0.5950	0.9895	5.5800	
	WSID	0.7212	0.9872	7.0100	

Process Verification

The sensitivity of the formula parameters is studied in the process by using PMHS data as "dummy" data. Theoretically when PMHS data are used as "dummy' data and plugged into the formula, they should yield a good or passing score because they are the very data used as the baseline to form the dummy evaluation equations. To confirm this, several trials are run to examine the robustness and practicability of the method. The scheme is verified using several arbitrarily picked PMHSs as "pseudo dummy" data.

Discussion

Differences exist between ISO9790, Maltese's method, and the cross-correlation based approach proposed by this study, e.g. the corridor definitions and the way dummies are judged. ISO9790 does not shift the signals. Maltese's method shifts the time histories based on the minimum cumulative variance relative to a master time history. ISO corridors often contain all the normalized response data within its corridors while the Maltese corridors use the signal mean plus and minus one standard deviation as the upper and lower boundaries. Three key differences between ISO9790, the Maltese method, and the approach herein are the algorithms used, the corridor definitions, and the way dummies are judged. Table A2 gives a brief summary of differences between the three evaluation schemes.

Summary

A cross-correlation based evaluation scheme is proposed. The statistical characteristics of the relationship between human surrogate and ATD impact response time histories are used to evaluate the ATD's bio-fidelity. The evaluation is done by determining if the ATD impact response time history of a given anatomical structure is statistically similar to that of the impact response time history of the anatomical structure in the human surrogates used for comparison. Three key parameters are used: magnitude correlation, shape correlation, and the phase relationship between different anatomical regions. The data relevancy is determined by kinematical factors such as conservation of momentum. The proposed approach eliminates the requirements for time shifting. The process is similar to the cumulative variance technique used in Maltese's method. It continues the work of Maltese with respect to reducing the human intervention in the existing bio-fidelity rating schemes.

Using this proposed bio-fidelity evaluation scheme, if an ATD's statistical relationships to the PMHSs are equal to or greater than the statistical relationships between PMHSs, it is considered to be bio-fidelic. If the statistical relationships are in the same ranges as that of the PMHSs, it is considered to be acceptable. If it is below the PMHSs, it is considered to have low bio-fidelity.

The process discussed in this paper is merely the framework of a side impact dummy evaluation scheme. Complete evaluation of a particular dummy requires additional work to finalize and test the scheme. Also, the proposed scheme at the time of this publication is not ready to be used for dummy design guidance. In other words, although the proposed approach certainly provides a tool for dummy evaluation, it does not provide provisions for dummy development targets. There is no corridor or curve to design a dummy to, as the ISO and Maltese methods have. Additional work will be needed to develop a similar design tool.

Further Work

More work remains to be done before this approach will be in its final form. At this time, a complete evaluation of a dummy is yet to be performed. On one hand, a more comprehensive PMHS database is needed. Without that, a reasonable statistical meaning of the scheme can not be achieved. Fortunately, thanks to the approach's flexibility, the scheme can be easily updated as additional data becomes available. On the other hand, how the correlation method should be formulated to achieve the best representation of the dummy's bio-fidelity remains to be further explored. How the weights should be applied to achieve the best balance of all the relevant factors in the formula, (i.e. how the three correlation indicators should be weighed and combined and

whether their product or summation should be used) remains to be answered. In addition, where to draw the line between the acceptable or not-acceptable ATDs is also somewhat subjective in the proposed approach. Whether a physical corridor or a score should be used as the rating tool remains to be decided. Whether the power statistics, T-square or some other approach should be used is to be studied as well. Whether the test data should be screened for adequacy, and how that should be done, is yet to be agreed upon by researchers in the field. All in all, there is a lot of work yet to be done, but this proposed ATD evaluation scheme provides a promising alternative in applying correlation tools in side impact dummy bio-fidelity evaluation.

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REFERENCES

Eppinger, R.H., Marcus, J.H., and Morgan, R.M., (1984) Development of dummy and injury index for NHTSA's thoracic side impact protection research program. Proc. SAE Government/industry Meeting, pp. 983-101 1. Society of Automotive Engineers, Warrendale, PA.

Hsu, T.P., Nusholtz, G.S. (2004) 31st Annual international Workshop on Human Subjects for Biomechanical research

Hsu, T. P, Nusholtz, G. S. (2005) Considerations of Bio-fidelity Corridors for Lateral Impacts, SAE Technical Paper Series 2005-01-0308, April 11, 2005

Irwin, A. L.; Sutterfield, A.; Hsu, T. P.; Kim, A.; Mertz, H. J.; Rouhana, S. W.; Scherer, R. (2005) Side impact response corridors for the rigid flat-wall and offset-wall side impact tests of NHTSA using the ISO method of corridor development. Occupant Safety Research Partnership, Mich. 34 p. Stapp car crash journal. Vol. 49 (Nov. 2005) p. 423-456.

ISO/TR9790. (1999) Road Vehicles Anthropomorphic Side Impact Dummy - Lateral Impact Response Requirements to Assess the Bio-fidelity of the Dummy. International Standards Organization, American National Standards Institute, NY, NY.

Maltese, M. R.; Eppinger, R. H.; Rhule, H. H.; Donnelly, B. R.; Pintar, F. A.; Yoganandan, N. (2002) Response corridors of human surrogates in lateral impacts. National Highway Traffic Safety Administration, Washington, D.C./ Wisconsin Medical College, Milwaukee/ Veterans Affairs Medical Center, Milwaukee, Wisc. 31 p. Stapp Car Crash Journal, Vol. 46, Nov. 2002, p. 321-351.

Rhule, H. H.; Maltese, M. R.; Donnelly, B. R.; Eppinger, R. H.; Brunner, J. K.; Bolte, J. H.. (2002) Development of a new bio-fidelity ranking system for anthropomorphic test devices. National Highway Traffic Safety Administration, Washington, D.C./ Transportation Research Center, East Liberty, Ohio. 36 p. Stapp Car Crash Journal, Vol. 46, Nov. 2002, p. 477-512.

Xu, L.; Agaram, V.; Rouhana, S.; Hultman, R. W.; Kostyniuk, G.W.; McCleary, J.; Mertz, H.; Nusholtz, G.S.; and Scherer, R.. (2000) Repeatability Evaluation of the Pre-Prototype NHTSA Advanced Dummy Compared to the Hybrid III, SAE Technical Paper Series 2000-01-0165, March6-9, 2000

APPENDIX A

Table A1.
Sample results of bio-fidelity score calculation

	1	2	3	4	5	6	7	8	9	10
1										Score
2	PHF									Scales of 0-10
3				Magnitude		Shape		Phase	Duration (period)	10 being the most Biofidelic
4	Thorax									
5		PMHS	ave Mag	0.8185	ave. shape	0.9960	ave phase	0.3189	53.75	
6		PMHS	wst Mag	0.7265	wst shape	0.9920				
7										
8		SID		0.2683		0.9767		5.0900		
9		ES-2		0.5950		0.9895		5.5800		
10		WSID		0.7212		0.9872		7.0100		
11										
12	Normalized	SID		0.3278		0.9806		0.9107		2.9
13	Normalized	ES-2		0.7269		0.9935		0.9015		6.5
14	Normalized	WSID		0.8811		0.9912		0.8748		7.6
15										
16	Abdomen									
17		PMHS	ave Mag	0.9164	ave. shape	0.9945	ave phase	0.2706	42.19	
18		PMHS	wst Mag	0.7104	wst shape	0.9937				
19										
20		SID		0.6232		0.9736		5.4911		
21		ES-2		0.8160		0.9830		5.4018		
22		WSID		0.7246		0.9809		6.2500		
23										
24	Normalized	SID		0.6801		0.9790		0.8755		5.8
25	Normalized	ES-2		0.8904		0.9884		0.8776		7.7
26	Normalized	WSID		0.7907		0.9863		0.8574		6.7
27										
28	Pelvis									
29		PMHS	ave Mag	0.8841	ave. shape	0.9965	ave phase	0.2296	40.00	
30		PMHS	wst Mag	0.8650	wst shape	0.9934				
31										
32		SID		0.5762		0.9844		6.4732		
33		ES-2		0.7198		0.9926		4.6429		
34		WSID		0.8729		0.9850		6.6518		
35										
36	Normalized	SID		0.6517		0.9879		0.8430		5.4
37	Normalized	ES-2		0.8142		1.0000		0.8890		7.2
38	Normalized	WSID		0.9873		1.0000		0.8385		8.3

Due to lack of data availability, some of the results shown are not based on a complete data set.

Table A2.
Comparison of different side impact dummy evaluation schemes

	ISO/TR9790	Maltese	Correlation
Evaluation	Expert evaluation	Statistical variance	Statistical correlation
Data screening	Severe rib fracture eliminated	No data exclusion	Irrelevant data eliminated through the momentum conservation theorem
Corridors	Upper and lower corridors	Mean +/- one standard deviation corridors	No physical corridors
Alignment	Manual alignment with some relative timing conservation	Alignment based on minimum variance	Alignment through correlation phase indicator
Processing	Manual processing	Automatic processing	Automatic processing
Numeric issues	No known numeric issues	The standard curve selection leading to variability	No known numeric issues
Numeric issues		Negative corridor issue	
Numeric issues		Some irregular corridors (zero corridor width) or corridors with less physical meaning	
Numeric issues		Sometimes unstable outcome due to integration time window	
Update	Update with new test data cumbersome	Updatable	Easily updatable
Manual work	More human interventions	Less human interventions	Minimum human intervention
Design guideline	Provides design guidance	Provides design guidance	Does not provide design guidance