1

A computational method for the design of an additively manufactured personalized artificial spinal disc with physiological stiffness under multiple loading conditions [Texto impreso] / Zhiyang Yu, Kristina Shea, Tino Stankovic

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101406(10)

The main limitations of currently available artificial spinal discs are geometric unfit and unnatural motion. Multi-material additive manufacturing (AM) offers a potential solution for the fabrication of personalized free-form implants with a better fit and variable material distribution to achieve a set of target physiological stiffnesses. The structure of the artificial spinal disc proposed in this paper is inspired from a natural disc and includes both a matrix and a crisscross fiber-like structure, where the design variables are their material properties. After carrying out design variable reduction using linking strategies, a finite element-based optimization is then conducted to calculate the optimized material distribution to achieve physiological stiffness under five loading cases. The results show a good match in stiffness of the multi-material disc compared with the natural disc and that the multi-material artificial disc outperforms a current known solution, the ball-and-socket disc. Moreover, the potential of achieving an improved match in stiffness with a larger range of available 3D printable materials is demonstrated. Although the direct surgical implantation of the design is hindered currently by the biocompatibility of the 3D printed materials, a potential improvement of the design proposed is shown.

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2

Augmented single loop single vector algorithm using nonlinear approximations of constraints in reliability-based design optimization [Texto impreso] / Petter N. Lind, Marten Olsson

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101403(9)

Reliability-based design optimization (RBDO) aims at minimizing a function of probabilistic design variables, given a maximum allowed probability of failure. The most efficient methods available for solving moderately nonlinear problems are single loop single vector (SLSV) algorithms that use a first-order approximation of the probability of failure in order to rewrite the inherently nested structure of the loop into a more efficient single loop algorithm. The research presented in this paper takes off from the fundamental idea of this algorithm. An augmented SLSV algorithm is proposed that increases the rate of convergence by making nonlinear approximations of the constraints. The nonlinear approximations are constructed in the following way: first, the SLSV experiments are performed. The gradient of the performance function is known, as well as an estimate of the most probable failure point (MPP). Then, one extra experiment, a probe point, per performance function is conducted at the first estimate of the MPP. The gradient of each performance function is not updated but the probe point facilitates the use of a natural cubic spline as an approximation of an augmented MPP estimate. The SLSV algorithm using probing (SLSVP) also incorporates a simple and effective move limit (ML) strategy that also minimizes the heuristics needed for initiating the optimization algorithm. The size of the forward finite difference design of experiment (DOE) is scaled proportionally with the change of the ML and so is the relative position of the MPP estimate at the current iteration. Benchmark comparisons against results taken from the literature show that the SLSVP algorithm is more efficient than other established RBDO algorithms and converge in situations where the SLSV algorithm fails.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 101403(1-9)

3

Bayesian optimal design of experiments for inferring the statistical expectation of expensive black-box functions [Texto impreso] / Piyush Pandita, Ilias Bilionis, Jitesh Panchal

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101404(10-11)

Bayesian optimal design of experiments (BODEs) have been successful in acquiring information about a quantity of interest (QoI) which depends on a black-box function. BODE is characterized by sequentially querying the function at specific designs selected by an infill-sampling criterion. However, most current BODE methods operate in specific contexts like optimization, or learning a universal representation of the black-box function. The objective of this paper is to design a BODE for estimating the statistical expectation of a physical response surface. This QoI is omnipresent in uncertainty propagation and design under uncertainty problems. Our hypothesis is that an optimal BODE should be maximizing the expected information gain in the QoI. We represent the information gain from a hypothetical experiment as the Kullback–Liebler (KL) divergence between the prior and the posterior probability distributions of the QoI. The prior distribution of the QoI is conditioned on the observed data, and the posterior distribution of the QoI is conditioned on the observed data and a hypothetical experiment. The main contribution of this paper is the derivation of a semi-analytic mathematical formula for the expected information gain about the statistical expectation of a physical response. The developed BODE is validated on synthetic functions with varying number of input-dimensions. We demonstrate the performance of the methodology on a steel wire manufacturing problema.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 101404(1-11)

1. Bayesian inference 2. Gaussian processes 3. Information gain 4. Kullback-Leibler divergence 5. Optimal experimental design 6. Uncertainty quantification

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4

Data-driven design space exploration and exploitation for design for additive manufacturing [Texto impreso] / Yi Xiong ... [et al.]

References: p. 101101(11-12)

Recently, design for additive manufacturing has been proposed to maximize product performance through the rational and integrated design of the product, its materials, and their manufacturing processes. Searching design solutions in such a multidimensional design space is a challenging task. Notably, no existing design support method is both rapid and tailored to the design process. In this study, we propose a holistic approach that applies data-driven methods in design search and optimization at successive stages of a design process. More specifically, a two-step surrogate model-based design method is proposed for the embodiment and detailed design stages. The Bayesian network classifier is used as the reasoning framework to explore the design space in the embodiment design stage, while the Gaussian process regression model is used as the evaluation function for an optimization method to exploit the design space in detailed design. These models are constructed based on one dataset that is created by the Latin hypercube sampling method and then refined by the Markov Chain Monte Carlo sampling method. This cost-effective data-driven approach is demonstrated in the design of a customized ankle brace that has a tunable mechanical performance by using a highly stretchable design concept with tailored stiffnesses.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 101101(1-12)

5

Design of a passive self-regulating gravity compensator for variable payloads [Texto impreso] / Dexter X. H. Chew, Kristin L. Wood, U.-Xuan Tan

References: p. 102302(11)

Most passive gravity balancing mechanisms (GBMs) require manual adjustment or actuators to alter its parameters for different payloads. The few balancers that passively self-regulate employ regulation at the end-effector, which makes the end-effector bulky. Additionally, there is a lack of systematic approach to design such compensators. Hence, this paper provides a review of current work which serves as the basis for a systematic design approach to solve the problem. Unlike previous designs, an independent self-regulating mechanism is mounted onto the proximal link of the GBM achieving better safety, larger range of motion, and loading at intermediate angles. The GBM is designed using design tools like functional modeling and morphological analysis with existing literature. This approach reveals design considerations of current GBMs and areas for innovation.

Design approaches from the literature are organized and serve as a reference for innovation. A prototype is developed, and experiments are performed to illustrate the capability.

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6

Design of conformal porous structures for the cooling system of an injection mold fabricated by additive manufacturing process [Texto impreso] / Yunlong Tang, Zhengyang Gao, Yaoyao Fiona Zhao

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101702(11)

The cooling system of plastic injection mold plays a critical role during the injection molding process. It not only affects part quality but also its cycle time. Traditionally, due to the limitations of conventional drilling methods, the cooling system of the injection mold usually consists of simple paralleled straight channels. It seriously limits the mobility of cooling fluid, which leads to the low cooling efficiency for the parts with complex free-form surfaces. In this research, an innovative design method for the cooling system of an injection mold is proposed by using conformal porous structures. The size and shape of each cell in the conformal porous structure are varied according to the shape of an injection molded part. Design cases are provided at the end of this paper to further illustrate the efficiency of the proposed method. Compared with those existing design methods for the uniform porous structures, the proposed method can further reduce the nonuniformity of the mold surface temperature distribution and decrease the pressure drop of the cooling system.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 101702(1-11)
1. Additive manufacturing 2. Conformal cooling 3. Design method 4. Injection mold 5. Porous structures

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7

Do student trials predict what professionals value in sustainable design practices? [Texto impreso] / Jeremy Faludi ... [et al.]

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 102001(12)

When teaching sustainable design in industry or academia, we should teach design methods, activities, and mindsets that are most effective at driving real change in a industry. However, most studies of design practices are performed on students, not on professionals. How strongly do student perceptions of value predict those of industry teams designing real products? This study provided workshops on three sustainable design methods (The Natural Step, Whole System Mapping, and Biomimicry) for 172 professionals and 204 students, applying the methods to their actual products being developed. It surveyed both populations about which activities or mindsets within each design method provided sustainability value, innovation value, and overall value. Quantitatively, student results did not strongly predict professional opinions; professionals chose clearer favorites and valued more things. However, qualitatively, student results did predict the reasons why professionals would value the design activities and mindsets. Therefore, care should be taken to choose appropriate participants for the questions being asked in sustainable design research.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 102001(1-12)
1. Design education 2. Design for environment 3. Design education 4. Design methodology 5. Design methods 6. Design process 7. Product design 8. Sustainable design

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8

A flexible chain proposal for winch-based point absorbers [Texto impreso] / Kjell Andersson, Anders Hagnestål, Ulf Sellgren

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.

References: p. 102301(8-9)

Ocean wave power is a promising renewable energy source. It has, however, been difficult to find a cost-effective solution to convert wave energy into electricity. The harsh marine environment and the fact that wave power is delivered with large forces at low speed make design of durable mechanical structures and efficient energy conversion challenging. The dimensioning forces strongly depend on the wave power concept, the wave energy converter (WEC) implementation, and the actual power take-off (PTO) system. A WEC with a winch as a power take-off system, i.e., a winch-based point absorber (WBPA), could potentially enable a low levelized cost of energy (LCOE) if a low-cost, durable and efficient winch that can deal with peak loads can be developed. A key challenge for realizing such a winch is to find a force transmitting solution that can deal with these peak loads and that can handle up to 80 million cycles during its life. In this article, we propose a design solution for a force transmitting chain with elastomer bearings connecting the links of the chain. With this solution no sliding is present, and the angular motion is realized as elastic shear deformations in the elastomer bearings when the chain is wound onto the winch drum. The elastomer bearings were designed for low shear stiffness and high compression stiffness, and the links were designed primarily to minimize the number of joints in the chain. Thereby, the maximum allowed relative angle between the links when rolled up over the drum should be as large as possible within practical limits. Finite element-based topological optimization was performed with the aim to increase the link strength to weight ratio. A test rig for a first proof of concept testing has been developed, and preliminary test results indicate that this chain concept with elastomer bearings can be a potential solution for a durable chain and should be analyzed and tested further for fatigue and sea operations.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 102301(1-9)
1. Chain transmission 2. Elastomer bearing 3. Power take-off system 4. Wave power

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9

Isomorphism detection of planar kinematic chains with multiple joints using information theory [Texto impreso] / Rajneesh Kumar Rai, Sunil Punjabi

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.

References: p. 102303(12)

Isomorphism (structural similarity) of kinematic chains (KCs) of mechanisms is an important issue in the structural synthesis, which must be identified to avoid the duplicate structures. Duplication causes incorrect family size, i.e., distinct KCs with a given number of links (n) and degree of freedom (dof). Besides simple joints kinematic chains (SJKCs), multiple joints kinematic chains (MJKCs) are also widely used because of their compact size and the methods dealing with such KCs are few. The proposed method deals with two different structural invariants, i.e., primary structural invariants (provide only the necessary condition of isomorphism), such as link connectivity number (LCN) of all the links, link connectivity number of chain (CCN), joint connectivity number (JCN) of all the joints, and joint connectivity number of chain (JCNC), and secondary structural invariants (provide the sufficient condition of isomorphism), such as power transmission (P) and transmission efficiency (Te). Primary structural invariants are calculated using a new link–link connectivity matrix (LLCM), whereas secondary structural invariants are calculated using the concept of entropy of information theory. The method has been successfully tested for 10 and 11 links MJKCs (illustrative examples taken in the paper) and for the families of 18 MJKCs with 8 links, 2 MJs, 1-dof, and 3 independent loops; 22 MJKCs with 8 links, 1 MJ, 1-dof, and 3 independent loops; and 83 MJKCs with 9 links, 1 MJ, 2-dof, and 3 independent loops.

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10

Maximum entropy method-based reliability analysis with correlated input variables via hybrid dimension-reduction method [Texto impreso]/ Wanxin He, Gang Li, Peng Hao, Yan Zeng

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.

References: p. 101405(13)

The estimation of the statistical moments is widely involved in the industrial application, whose accuracy affects the reliability analysis result considerably. In this study, a novel hybrid dimension-reduction method based on the

Nataf transformation is proposed to calculate the statistical moments of the performance function with correlated input variables. Nataf transformation is intrinsically the Gaussian copula, which is commonly used to transform the correlated input variables into independent ones. To calculate the numerical integration of the univariate component function in the proposed method, a normalized moment-based quadrature rule is employed. According to the statistical moments obtained by the proposed method, the probability density function of the performance function can be recovered accurately via maximum entropy method. Six examples are tested to illustrate the accuracy and efficiency of the proposed method, compared with that of Monte Carlo simulation, the conventional univariate dimension-reduction method, and the bivariate dimension-reduction method. It is confirmed that the proposed method achieves a good tradeoff between accuracy and efficiency for structural reliability analysis with correlated input variables.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 101405(1-13)
1. Dimension-reduction method 2. Gaussian copula 3. Maximum entropy method 4. Nataf transformation 5. Normalized moment-based quadrature rule 6. Structural reliability

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11

Predicting demand of distributed product service systems by binomial parameter mapping [Texto impreso] : a case study of bike sharing station expansion / Bryan C. Watson, Cassandra Telenko

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101701(11-12)

Quantitative approaches for estimating user demand provide a powerful tool for engineering designers. We hypothesized that estimating binomial distribution parameters n (user population size) and p (user population product affinity) from historical user data can predict demand in new situations for distributed product service systems. Distributed product service systems allow individuals to use shared products at different geographic locations as opposed to owning them. This approach is demonstrated on a major bike-sharing system (BSS) expansion. BSSs position rental bikes around a city in docks at prescribed locations. BSS operators must predict the rider demand when sizing new docking stations, but current demand estimation methods may not be suitable for distributed systems. The main contribution of this paper is the development and application of a revealed preference demand estimation method for distributed product service systems. While much current research seeks to solve distributed system operational problems, we estimate the user population characteristic to provide insight into the initial installation design problem. We introduce the use of spatial surface plots to extrapolate binomial parameters n and p over the service area. These surfaces allow more accurate prediction of relative ridership levels at new station locations. By utilizing Spearman's rho as a comparison benchmark, our approach yields a stronger correlation between our prediction and the observed new station utilization (rho = 0.83, stations = 46, $p < 0.01$) than the order implemented by the BSS operator (rho = 0.59, stations = 46, $p < 0.01$).

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 101701(1-12)
1. Data-driven design 2. Demand estimation algorithm 3. Distributed systems 4. Product service systems bike share 5. Revealed preference

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12

A problem class with combined architecture, plant, and control design applied to vehicle suspensions [Texto impreso] / Daniel R. Herber , James T. Allison

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101401(11)

Here we describe a problem class with combined architecture, plant, and control design for dynamic engineering systems. The design problem class is characterized by architectures comprised of linear physical elements and nested co-design optimization problems employing linear-quadratic dynamic optimization. The select problem class leverages a number of existing theory and tools and is particularly effective due to the symbiosis between labeled graph representations of architectures, dynamic models constructed from linear physical elements, linear-quadratic dynamic optimization, and the nested co-design solution strategy. A vehicle suspension case study is investigated and a specifically constructed architecture, plant, and control design problem is described. The result was the automated generation and co-design problem evaluation of 4374 unique suspension architectures. The results

demonstrate that changes to the vehicle suspension architecture can result in improved performance, but at the cost of increased mechanical complexity. Furthermore, the case study highlights a number of challenges associated with finding solutions to the considered class of design problems. One such challenge is the requirement to use simplified design problem elements/models; thus, the goal of these early-stage studies are to identify new architectures that are worth investigating more deeply. The results of higher-fidelity studies on a subset of high-performance architectures can then be used to select a final system architecture. In many aspects, the described problem class is the simplest case applicable to graph-representable, dynamic engineering systems.

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13

A spatial grammar method for the computational design synthesis of virtual soft locomotion robots [Texto impreso] / Merel van Diepen, Kristina Shea

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 101402(9-10)

Soft locomotion robots are intrinsically compliant and have a large number of degrees of freedom. They lack rigid components that provide them with higher flexibility, and they have no joints that need protection from liquids or dirt. However, the hand-design of soft robots is often a lengthy trail-and-error process. This work presents the computational design of virtual, soft locomotion robots using an approach that integrates simulation feedback. The computational approach consists of three stages: (1) generation, (2) evaluation through simulation, and (3) optimization. Here, designs are generated using a spatial grammar to explicitly guide the type of solutions generated and exclude infeasible designs. The soft material simulation method developed and integrated is stable and sufficiently fast for use in a highly iterative simulated annealing search process. The resulting virtual designs exhibit a large variety of expected and unexpected gaits, thus demonstrating the method capabilities. Finally, the optimization results and the spatial grammar are analyzed to understand and map the challenges of the problem and the search space.

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14

Static and dynamic transmission error measurements of helical gear pairs with various tooth modifications [Texto impreso] / M. Benatar, M. Handschuh, A. Kahraman, D. Talbot

Este artículo se encuentra disponible en su edición impresa y electrónica. Los datos para su localización están accesibles a través del enlace al título de la publicación. Su acceso electrónico es a través del enlace de 'Acceso al documento'.
References: p. 103301(11)

This paper presents a set of motion transmission error data for a family of helical gears having different profile and lead modifications operated under both low-speed (quasi-static) and dynamic conditions. A power circulatory test machine is used along with encoder and accelerometer-based transmission error measurement systems to quantify motion transmission behavior within wide ranges of torque and speed. Results of these experiments indicate that the tooth modifications impact the resultant static and dynamic transmission error amplitudes significantly. A design load is shown to exist for each gear pair of different modifications where static transmission error amplitude is minimum. Forced response curves and waterfall plots are presented to demonstrate that the helical gear pairs tested act linearly with no signs of nonlinear behavior such as tooth contact separations. Furthermore, static and dynamic transmission error amplitudes are observed to be nearly proportional, suggesting that static transmission error can be employed in helical gear dynamic models as the main gear mesh excitation. The data presented here is intended to fill a void in the literature by providing means for validation of load distribution and dynamic models of helical gear pairs.

Journal of mechanical design. -- 2019 (October), v. 141, n. 10, p. 103301(1-11)
1. Dynamic transmission error 2. Helical gear dynamics 3. Static transmission error

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