**1**

**A case study of deep reinforcement learning for engineering design [Texto impreso] : application to microfluidic devices for flow sculpting / Xian Yeow Lee ... [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. 111401(9-10)

Efficient exploration of design spaces is highly sought after in engineering applications. A spectrum of tools has been proposed to deal with the computational difficulties associated with such problems. In the context of our case study, these tools can be broadly classified into optimization and supervised learning approaches. Optimization approaches, while successful, are inherently data inefficient, with evolutionary optimization-based methods being a good example. This inefficiency stems from data not being reused from previous design explorations. Alternately, supervised learning-based design paradigms are data efficient. However, the quality of ensuing solutions depends heavily on the quality of data available. Furthermore, it is difficult to incorporate physics models and domain knowledge aspects of design exploration into pure-learning-based methods. In this work, we formulate a reinforcement learning (RL)-based design framework that mitigates disadvantages of both approaches. Our framework simultaneously finds solutions that are more efficient compared with supervised learning approaches while using data more efficiently compared with genetic algorithm (GA)-based optimization approaches. We illustrate our framework on a problem of microfluidic device design for flow sculpting, and our results show that a single generic RL agent is capable of exploring the solution space to achieve multiple design objectives. Additionally, we demonstrate that the RL agent can be used to solve more complex problems using a targeted refinement step. Thus, we address the data efficiency limitation of optimization-based methods and the limited data problem of supervised learning-based methods. The versatility of our framework is illustrated by utilizing it to gain domain insights and to incorporate domain knowledge. We envision such RL frameworks to have an impact on design science.

Journal of mechanical design. -- 2019 (November), v. 141, n. 11, p. 111401(1-10)

1. Computer-aided engineering 2. Deep learning 3. Deep reinforcement learning 4. Design automation 5. Design methodology 6. Design optimization 7. Generative design 8. Multidisciplinary design and optimization

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**2**

**Data-driven design of control strategies for distributed energy systems [Texto impreso] / Philip Odonkor, Kemper Lewis**

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. 111404(10)

The flexibility afforded by distributed energy resources in terms of energy generation and storage has the potential to disrupt the way we currently access and manage electricity. But as the energy grid moves to fully embrace this technology, grid designers and operators are having to come to terms with managing its adverse effects, exhibited through electricity price volatility, caused in part by the intermittency of renewable energy. With this concern however comes interest in exploiting this price volatility using arbitrage—the buying and selling of electricity to profit from a price imbalance—for energy cost savings for consumers. To this end, this paper aims to maximize arbitrage value through the data-driven design of optimal operational strategies for distributed energy resources (DERs). Formulated as an arbitraje maximization problem using design optimization principles and solved using reinforcement learning, the proposed approach is applied toward shared DERs within multi-building residential clusters. We demonstrate its feasibility across three unique building clusters, observing notable energy cost reductions over baseline values. This highlights a capability for generalized learning across multiple building clusters and the ability to design efficient arbitrage policies for energy cost minimization. The scalability of this approach is studied using two test cases, with results demonstrating an ability to scale with relatively minimal additional computational cost, and an ability to leverage system flexibility toward cost savings.

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1. Battery storage 2. Building cluster 3. Data-driven design 4. Operational Strategy design 5. Reinforcement learning

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**3**

**A data-driven methodology to construct customer choice sets using online data and customer reviews [Texto impreso] : imitating human designers through deep learning / Dedy Suryadi, Harrison M. Kim**

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. 111103(12)

The recent development in engineering design has incorporated customer preferences by involving a choice model. In generating a choice model to produce a good quality estimate of parameters related to product attributes, a high-quality choice set is essential. However, the choice set data are often not available. This research proposes a methodology that utilizes online data and customer reviews to construct customer choice sets in the absence of both the actual choice set and the customer sociodemographic data. The methodology consists of three main parts, i.e., clustering the products based on their attributes, clustering the customers based on their reviews, and constructing the choice sets based on a sampling probability scenario that relies on product and customer clusters. The proposed scenario is called Normalized, which multiplies the product cluster and customer cluster fractions to obtain the probability sampling distribution. There are two utility functions proposed, i.e., a linear combination of product attributes only and a function that includes the interactions of product attributes and customer reviews. The methodology is implemented to a data set of laptops. The Normalized scenario performs significantly better than the baseline, Random, in predicting the test set data. Moreover, the inclusion of customer reviews into the utility function also significantly increases the predictive ability of the model. The research shows that using the product attribute data and customer reviews to construct choice sets generates choice models with higher predictive ability than randomly constructed choice sets.

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1. Choice model 2. Choice set 3. Design automation 4. Online customer reviews

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**4**

**Deep generative design [Texto impreso] : integration of topology optimization and generative models / Sangeun Oh ... [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. 111405(13)

Deep learning has recently been applied to various research areas of design optimization. This study presents the need and effectiveness of adopting deep learning for generative design (or design exploration) research area. This work proposes an artificial intelligent (AI)-based deep generative design framework that is capable of generating numerous design options which are not only aesthetic but also optimized for engineering performance. The proposed framework integrates topology optimization and generative models (e.g., generative adversarial networks (GANs)) in an iterative manner to explore new design options, thus generating a large number of designs starting from limited previous design data. In addition, anomaly detection can evaluate the novelty of generated designs, thus helping designers choose among design options. The 2D wheel design problem is applied as a case study for validation of the proposed framework. The framework manifests better aesthetics, diversity, and robustness of generated designs than previous generative design methods.

Journal of mechanical design. -- 2019 (November), v. 141, n. 11, p. 111405(1-13)

1. Design automation 2. Design exploration 3. Design methodology 4. Design optimization 5. Deep learning 6. Expert systems 7. Generative adversarial networks 8. Generative design 9. Generative models 10. Product design 11. Topology optimization

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**5**

**Design repository effectiveness for 3D convolutional neural networks [Texto impreso] : application to additive manufacturing/ Glen Williams, Nicholas A. Meisel, Timothy W. Simpson, Christopher McComb**

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. 111701(11-12)

Machine learning can be used to automate common or time-consuming engineering tasks for which sufficient data already exist. For instance, design repositories can be used to train deep learning algorithms to assess component manufacturability; however, methods to determine the suitability of a design repository for use with machine learning do not exist. We provide an initial investigation toward identifying such a method using “artificial” design repositories to experimentally test the extent to which altering properties of the dataset impacts the assessment precision and generalizability of neural networks trained on the data. For this experiment, we use a 3D convolutional neural network to estimate quantitative manufacturing metrics directly from voxel-based component geometries. Additive manufacturing (AM) is used as a case study because of the recent growth of AM-focused design repositories such as GrabCAD and Thingiverse that are readily accessible online. In this study, we focus only on material extrusion, the dominant consumer AM process, and investigate three AM build metrics: (1) part mass, (2) support material mass, and (3) build time. Additionally, we compare the convolutional neural network accuracy to that of a baseline multiple linear regression model. Our results suggest that training on design repositories with less standardized orientation and position resulted in more accurate trained neural networks and that orientation-dependent metrics were harder to estimate than orientation-independent metrics. Furthermore, the convolutional neural network was more accurate than the baseline linear regression model for all build metrics.

Journal of mechanical design. -- 2019 (November), v. 141, n. 11, p. 111701(1-12)

1. Design automation 2. Design evaluation 3. Design for manufacturing

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**6**

**Evolving a psycho-physical distance metric for generative design exploration of diverse shapes [Texto impreso] / Shahroz Khan, Erkan Gunpinar, Masaki Moriguchi, Hiromasa Suzuki**

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. 111101(12-13)

In this paper, a generative design approach is proposed that involves the users’ psychological aspect in the design space exploration stage to create distinct design alternatives. Users’ perceptual judgment about designs is extracted as a psycho-physical distance metric, which is then integrated into the design exploration step to generate design alternatives for the parametric computer-aided design (CAD) shapes. To do this, a CAD model is first parametrized by defining geometric parameters and determining ranges of these parameters. Initial design alternatives for the CAD model are generated using Euclidean distance-based sampling teaching–learning-based optimization (S-TLBO), which is recently proposed and can sample N space-filling design alternatives in the design space. Similar designs are then clustered, and a user study is conducted to capture the subjects’ perceptual response for the dissimilarities between the cluster pairs. In addition, a furthest-point-sorting technique is introduced to equalize the number of designs in the clusters, which are being compared by the subjects in the user study. Afterward, nonlinear Regression analyses are carried out to construct a mathematical correlation between the subjects’ perceptual response and geometric parameters in the form of a psycho-physical distance metric. Finally, a psycho-physical distance metric obtained is utilized to explore distinct design alternatives for the CAD model. Another user study is designed to compare the diversification between the designs when the Euclidean and the suggested psycho-physical distance metrics are utilized. According to the user study, designs generated with the latter metric are more distinct.

Journal of mechanical design. -- 2019 (November), v. 141, n. 11, p. 111101(1-13)

1. Computer-aided design 2. Generative design 3. S-TLBO 4. Space-filling 5. Parametric design

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**7**

**Globally approximate gaussian processes for big data with application to data-driven metamaterials design [Texto impreso] / Ramin Bostanabad ... [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. 111402(10-11)

We introduce a novel method for Gaussian process (GP) modeling of massive datasets called globally approximate Gaussian process (GAGP). Unlike most large-scale supervised learners such as neural networks and trees, GAGP is easy to fit and can interpret the model behavior, making it particularly useful in engineering design with big data. The key idea of GAGP is to build a collection of independent GPs that use the same hyperparameters but randomly distribute the entire training dataset among themselves. This is based on our observation that the GP hyperparameter approximations change negligibly as the size of the training data exceeds a certain level, which can be estimated systematically. For inference, the predictions from all GPs in the collection are pooled, allowing the entire training dataset to be efficiently exploited for prediction. Through analytical examples, we demonstrate that GAGP achieves very high predictive power matching (and in some cases exceeding) that of state-of-the-art supervised learning methods. We illustrate the application of GAGP in engineering design with a problem on data-driven metamaterials, using it to link reduced-dimension geometrical descriptors of unit cells and their properties. Searching for new unit cell designs with desired properties is then achieved by employing GAGP in inverse optimization.

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1. Big data 2. Design automation 3. Design optimization 4. Design representation 5. Gaussian processes 6. Metamaterials 7. Metamodelling 8. Supervised learning

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**8**

**Learning to design from humans [Texto impreso] : imitating human designers through deep learning / Ayush Raina, Christopher McComb, Jonathan Cagan**

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. 111102(10-11)

Humans as designers have quite versatile problem-solving strategies. Computer agents on the other hand can access large-scale computational resources to solve certain design problems. Hence, if agents can learn from human behavior, a synergetic human-agent problem-solving team can be created. This paper presents an approach to extract human design strategies and implicit rules, purely from historical human data, and use that for design generation. A two-step framework that learns to imitate human design strategies from observation is proposed and implemented. This framework makes use of deep learning constructs to learn to generate designs without any explicit information about objective and performance metrics. The framework is designed to interact with the problem through a visual interface as humans did when solving the problem. It is trained to imitate a set of human designers by observing their design state sequences without inducing problem-specific modeling bias or extra information about the problem. Furthermore, an end-to-end agent is developed that uses this deep learning framework as its core in conjunction with image processing to map pixel-to-design moves as a mechanism to generate designs. Finally, the designs generated by a computational team of these agents are then compared with actual human data for teams solving a truss design problem. Results demonstrate that these agents are able to create feasible and efficient truss designs without guidance, showing that this methodology allows agents to learn effective design strategies.

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1. Computer-aided design 2. Design automation 3. Design teams

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**9**

**Synthesizing designs with interpart dependencies using hierarchical generative adversarial networks [Texto impreso] / Wei Chen, Mark Fuge**



References: p. 111403(10-11)

Real-world designs usually consist of parts with interpart dependencies, i.e., the geometry of one part is dependent on one or multiple other parts. We can represent such dependency in a part dependency graph. This paper presents a method for synthesizing these types of hierarchical designs using generative models learned from examples. It decomposes the problem of synthesizing the whole design into synthesizing each part separately but keeping the interpart dependencies satisfied. Specifically, this method constructs multiple generative models, the interaction of which is based on the part dependency graph. We then use the trained generative models to synthesize or explore each part design separately via a low-dimensional latent representation, conditioned on the corresponding parent part(s). We verify our model on multiple design examples with different interpart dependencies. We evaluate our model by analyzing the constraint satisfaction performance, the synthesis quality, the latent space quality, and the effects of part dependency depth and branching factor. This paper's techniques for capturing dependencies among parts lay the foundation for learned generative models to extend to more realistic engineering systems where such relationships are widespread.

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