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Simulations of two lane traffic model with chaotic behaviour

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Abstract

Numerical experiments are the very basic tool for investigating of some interesting properties of traffic flow models. Two lane models with overtaking ability are the special case of them. The most interesting phenomena are creation and following disintegration of traffic jams, interaction between congested traffic lanes and statistic properties of this model. Traffic jam seems to be created by slow vehicle only if there is speed difference between lanes higher the some critical value. Disintegration on the other hand starts if fluctuations of vehicle speeds in "fast" lane are higher than some certain level. Interaction between congested traffic lanes means synchronization of speeds, which leads to very fast growth of their length. Finally, statistical properties shows very clear correlation between "quality" and "fluency" of traffic flow as recently introduced terms. These results bring new view to some traditional terms in traffic engineering, for example capacity as one of the main variables.

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Simulation of pedestrian movement using cellular automata models

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Abstract

Actual models used to simulate crowd dynamics can be sorted into three groups: force-based models, thermodynamic models, and cellular automata models - the last one is a subject of our investigation. The main idea of these models is stochastic update rules and discretization both in time and space. Furthermore we will present Floor field model for pedestrian movement inspired by ants communication. It is a cellular automata model in two dimension, where pedestrians move in lattice $M \times N$. Update rules contain repulsive force (between pedestrians themselves and between pedestrians and walls) and also pedestrians intention and herding. This section will be finished by presentation of simulation results. At the end, we will define simplified variant of this model for room evacuation. We will focus on potential in system generated by attractors (doors) and variants of pedestrian behavior. This article will be closed by presentation of results and plans for future upgrades.

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Dijkstra's Algorithm and Fast Marching Method in Acoustic Emission Geodetics

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Abstract

The presentation is related to Acoustic Emission (AE) principle, which is a Non-destructive Testing method (NDT) for structural health monitoring. The acoustic measuring devices Xedo-5 and IPL-3 recording the synchronous continuous 4chanels AE signals can be used for acoustic source localization on the surface of solid body, which is mathematically described as a conjunction of several simpler shapes of parametrized surfaces like cylinders, toroides, spheres, cones,... with intersections between them. Instead of complicated numerical computations of the geodetic equations solution, we describe and illustrate both the Dijkstra's algorithm (A-star extension) and Fast Marching algorithm for finding the geodetic curves. We develop and test the MATLAB programmes which are based on approximative solutions of the Eikonal discretized equation $|\nabla u| = F(x, y)$ while iteratively upgrading neighborhoods of relevant points of a chosen mesh. The efficiency and accuracy of the methods depends on the mesh used, that is why, we present the computing time comparisons of the algorithms for ordinary and Delaunay mesh. The specific examples for the case of simple and complex surface shapes with further applications will be given under the concept of Acoustic Emission source localization principle.

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Geometric Tangent Method for Geodetic Curves Construction (with Applications in AE)

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Abstract

The presentation concerns the localization of the defects on the surface of solid body, which is mathematically described as a conjunction of several simpler shapes of parametrized surfaces like cylinders, toroides, spheres, cones,... with intersections. The shortest path can be found through the geodesic equations (known from differential geometry) by means of the very extensive and complicated numerical computations like Functional Iterations or Newton-Raphson iterative method. Instead of this, we describe and illustrate the algorithm for finding the geodetic curves by applying geometric approach based on surface steps within the directions selected through the normal vector of tangent plane at sequentially proceeding points on the surface considered. The step length is adapted according to the curvature and the torsion of the surface. The specific examples and applications of the geometric algorithm will be given under the concept of Acoustic Emission source localization principle.

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Acoustic emission source identification by means of experimental signal deconvolution approach

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Abstract

Localization, identification and classification of acoustic sources is a great and the most important problem emerging in biomedical applications and nondestructive testing. We present the basics of Acoustic Emission (AE) principle and point out the advantages of AE nondestructive testing for localization and classification of acoustic sources. We deal with a very perspective extension of AE to the time-reversal (TR) acoustic diagnostics, which provides the tool for the defect localization by means of the reversal wave focusing in nonlinearity position in the material under consideration. Also, using TR operator to AE signal, we obtain convolutional signal in the closest neighborhood of acoustic source, which gives us the pure image of the real characteristics of AE source after deconvolution process applied to the signals detected. We describe the mathematical background for backside deconvolution through the Green functions. Further, we design the laboratory settings realizing experimental AE signal deconvolution of the reversed signals measured by the laser beam device centering to the position of the defect. Finally, we apply the recently developed classification methods to these signals based on the Fuzzy approach, Support Vector Machines technique and also using statistical tools such as model based parametric estimation of distribution mixtures with signal attributes computed via informational divergences and scores.

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Some computational aspects of robustified total least squares

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Abstract

Classical regression estimators, such as the Ordinary Least Squares, are very sensitive to occurrence of outliers and they are not consistent when orthogonality condition is broken and both independent and some dependent variables are considered to be measured with a random error. The method which can cope with this problem is robustified version of the mixed Least Squares - Total Least Squares, based on the idea of down-weighting the influential points. The existence and the uniqueness of the solution is discussed and different approaches of calculation are described. The computational complexity is shown and the exact algorithm based on a branch-and-bound technique that guarantees global optimality is presented. The imlementation of all algorithms and theirs application to simulated data sets are shown.

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Simulation of energy dissipation during concrete cracking

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Abstract

The failure of concrete structures is associated with crack initiation and propagation. Some phenomena, which still may be regarded as fundamental, haven't been adequately resolved and explained. One such phenomenon is the energy dissipation during the tensile failure (fracture) of quasi-brittle materials.

For better understanding numerical simulations of fractures are being carried out by means of physical discretization of continuum [**?**]. This discretiazation technique is similar to the lattice models and uses a procedure developed for rigid body spring networks [**?**, **?**]. The computational code developed for the simulations by the authors is based on a nonlinear dynamical description of the problem. Due to high computational demands, especially when a very fine mesh is needed, a parallel CUDA version has been employed. The results of such dynamical simulations are considered in this work to answer questions regarding the evolution of the (modelled) fracture process zone, the amount of dissipated energy, etc. The simulations also offer possibilities for the assessment of the acoustic-emission-like events provided by the fracture model and to compare this data with real acoustic emission data from the literature [**?**].

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Minimum Distance Based Identification of the Unknown Statistical Model

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Abstract

We apply the research results developed in [1] dealing with the minimum distance estimation techniques for various types of statistical distances on the space of probability distributions, e.g. Kolmogorov, Lévy, Cramer-von Mises, Discrepancy, and several divergences such as Hellinger squared distance or blended Le Cam divergence. Estimating the distributional parameters by means of the minimum distance method within the semi-parametric family of distributions, we try to obtain the correct identification of the statistical model hidden in the data generated during simulation process. We point out the problems of robust model identification under the ε-contaminated probabilities and we present the percentage proportions of false identifications for different sample sizes and selected distances and divergences in the frame of specific semi-parametric family of distributions.

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Generalized Cramér–von Mises distance estimators

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Abstract

Generalized Cramér–von Mises distance estimators of parameters in arbitrary model are investigated. Two different generalization of Cramér–von Mises distance are defined. First by replacing the second power in the original formula by general power α and second is the so called Kolmogorov–Cramér estimate. Its character is controlled by real valued parameter α and finite discrete parameter m which optionally depend on sample size n. Kolmogorov–Cramér estimate includes both Kolmogorov and Cramér–von Mises estimates as the limiting cases. For $m < 2n$ chosen arbitrary but fixed is Kolmogorov–Cramér estimate proven to be $n^{-1/2}$ consistent in L_1-norm and in the expected L_1-norm. For m dependent on sample size n ($m = f(n)$), the order $n^{-1/2}$ is not achieved, the order depends on function $f(n)$.

Further, computer simulation was produce to study robustness and efficiency for non-contaminated and contaminated sample of above mentioned estimates. Computer simulation compares behavior of Kolmogorov, Cramér–von Mises, generalized Ceamér–von Mises, and Kolmogorov–Cramer estimates. Resulting graphs are presented and discussed.

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On the Newcomb-Benford law

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Abstract

We consider positive real valued random data X with the decadic representation $X = \sum_{i=-\infty}^{\infty} D_i\, 10^i$ and the first significant digit $D = D(X) \in \{1, 2, \ldots, 9\}$ of X defined by the condition $D = D_i \geq 1,\ D_{i+1} = D_{i+2} = \ldots = 0$. The data X are said to satisfy the Newcomb-Benford law if $P\{D = d\} = \log_{10} \frac{d+1}{d}$ for all $d \in \{1, 2, \ldots, 9\}$. This law holds for example for the data with $\log_{10} X$ uniformly distributed on an interval (m, n) where m and n are integers. We show that if $\log_{10} X$ has a distribution function $G(x/\sigma)$ on the real line where $\sigma > 0$ and $G(x)$ has an absolutely continuous density $g(x)$ which is monotone on the intervals $(-\infty, 0)$ and $(0, \infty)$ then

$$\left| P\{D = d\} - \log_{10} \frac{d+1}{d} \right| \leq \frac{2\, g(0)}{\sigma}\ .$$

The constant 2 can be replaced by 1 if $g(x) = 0$ on one of the intervals $(-\infty, 0),\ (0, \infty)$. Further, the constant $2g(0)$ is to be replaced by $\int |g'(x)|\, dx$ if instead of the monotonicity we assume absolute integrability of the derivative $g'(x)$.

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Traffic Flow Characteristics of Totally Asymmetric Exclusion Process with Nearest-Particle Interaction

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Abstract

The one-dimensional lattice gas model with nearest-particle interaction based on the totally asymmetric exclusion process is considered. The generalized dynamics of the simple exclusion process is introduced for both, periodic boundary condition and open boundary condition. Because of its simplicity, this model is often used for highway traffic simulations. Our goal is to investigate the headway distribution for this model, to better understand the microscopic structure and compare it with the real highway traffic.

Considering the nearest-neighbor interaction, the analytical derivation of the time-headway distribution is presented. Due to the short interaction, the particle-hole symmetry appears and is reflected in the investigated characteristics. Nevertheless, the procedure provides a possible way for analyzing the time-headway distribution even for middle-ranged interaction model, which has been studied via computer simulations only.

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Lighthill-Whitham traffic model and analytical solution

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Abstract

Traffic modeling does not belong to sciences with long tradition, however even for such a modern topic a look back at the first attempts to describe traffic flow can be inspiring. Concentrating on models using macroscopical approach, the oldest model brings us back to the middle of last century. In 1955 M. J. Lighthill and G. B. Whitham developed fluid-dynamic model based on conservation of vehicle number. The simple idea that vehicles neither arise nor vanish on the road is in the model represented by the continuity equation

$$\frac{\partial \rho(x,t)}{\partial t} + \frac{\partial q(x,t)}{\partial x} = 0.$$

The traffic flow $q(x,t)$ could be calculated as the product of the traffic density $\rho(x,t)$ and velocity field $v(x,t)$. For further investigations the definition of relationship between density and velocity is needed. The simplest way is to use linear relation suggested by B. D. Greenshield already in 1933. With some modifications the model leads to Burgers partial differential equation, which could be solved by means of Cole-Hopf substitution.

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Matrix Reloaded

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Abstract

As well known, the microstructure of many theoretical or empirical systems corresponds (in a certain sense) to the configuration of eigenvalues generated by the Random Matrix Ensembles (like GUE, GOE, GSE, BRME). Especially, there exists a great set of physical/economy/social systems whose inter-particle gaps (here denoted by variable s) are distributed according to the formula

$$\wp(s) = A\Theta(s)s^{\beta}\mathrm{e}^{-Bs}, \quad A = A(\beta),\ B = B(\beta). \tag{1}$$

Surprisingly, inter-vehicle headways of vehicular systems do not correspond to the probability density (1). Instead, the detected gap distribution is of a form

$$\wp(s) = A\Theta(s)\mathrm{e}^{-\frac{\beta}{s}-Bs}, \quad A = A(\beta),\ B = B(\beta). \tag{2}$$

Long-lasting endeavour of contemporary mathematics is to discover new type of random matrices such that the associated level spacing is described by the function (2). We will demostrate a possible way how to attain it.

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Finding Chaos in GDP

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Abstract

The aim is to verify the presence of deterministic chaos in GDP and analyze GDP. I have tried to grasp the hidden essence of the problem in order to formulate a prediction more easily. The basic question is therefore the existence of chaotic behavior. If the system behaves chaotically, we are forced to accept only limited predictions. I have tried to show the chaotic behavior of GDP and then propose a simple lower-dimensional system under which the system evolves. I have calculated the Hurst exponent and I have estimated the correlation dimension of the GDP time series. I have analyzed GDP in phase space.

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Statistical analysis of traffic time series

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Abstract

Statistical analysis of traffic data from Dutch highway A9 was made in this contribution. Data was tested in goodness-of-fit with recently derived dense distribution for two different potentials (logarithmic and power-law). Moreover, tests of goodness-of-fit were performed for comparing the theoretical distribution function of time clearence with empirical one, and the theoretical distribution function of distance clearence with empirical one. From this statistical analysis, suggestions to improve thermodynamical traffic model was developed by using semi-Poisson model of queueing [4]. Recently, Helbing suggested to take correlation of velocity and time/space-headways in account [5]. In this contribution analysis of this suggestion was carried and examination of impact on our model was conducted.

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Structure identification by means of density estimation in PM space

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Abstract

We present the basic concepts of Preisach-Mayergoyz model (PM) of hysteresis phenomenon in nonlinear elastic spectroscopy environment. We explain the functionality of opening P_o and closing P_c pressures in the scalar Preisach triangular space for various types of hysteretic materials. To get insight into the structure of a given material under consideration, we need to identify the two-dimensional probability density function in PM space, which is allowed to be represented by Gauss-Gauss, Lognormal-Gauss, Factorized-Lorentzian type of distributions or by the restricted power distribution with two optional parameters α, β and under the maximal limit value chosen for the opening pressure. Further, the hysteresic behavior can be modeled in PM space by any other reasonable distributions connected to the real material structure (rocks, sand,...) or induced by some applications from textile, chemical, and biomedical treatments or e.g. in magnetics and electronics. We propose the iterative numerical procedure for finding the true density function of P_o and P_c pressures by means of discretization of the parametric space of the densities implemented in PM space model. To establish the closest similarity of the theoretical and experimental hysteresic loop, we apply the distance measures based on standard L2-norm or comparatively also on discrete versions of divergence measures coming from the information and statistical theory. Some preliminary results will be presented in the real PM space with $N = 100$ Hysteresic Elastic Units and $0 < P_o, P_c < 6$.

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Optimal velocity model

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Abstract

Optimal velocity model (Optvel) is a traffic model of Newtonian type. For a concrete choice of optimal velocity function it has been studied behaviour of this model. The results of microscopic (including calculation of spectral rigidity) and macroscopic analysis will be shown. Phenomenon of congestion has been reproduced with large variance of traffic flow. All results have been confronted with real traffic data. Dependence of fundamental diagrams on model parameters has been investigated and key parameter responsible for creation of congestion has been identified. Some technical and qualitative problems of Optvel will be discussed and modification of model dealing with presence of synchronized traffic regime will be presented.

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Benefits and Limits of the Distribution Mixture Algorithm in Various Statistical Applications

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Abstract

The distribution mixture (DM) is usually employed whenever there is a strong evidence of multimodality in the data. Our scope is the possible use of the distribution mixture as a model based method in various statistical applications, e.g. in econometrics or cluster analysis. The clusters are considered to be generated from the DM components with normal densities. We give the hints and restrictions for using DM in other cases and we describe the numerical tool for cluster finding through the mixture parameter estimation. Since each component of the distribution mixture should ideally refer to one cluster in the data, the problem of choosing an optimal number of components of the mixture becomes quite urgent. However, there is no definite answer to the problem of optimal number of components and the approach taken depends strongly on the judgement of the experimenter. We suggest some examples and applications of such a signal processing procedure in the real practice.

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Time Reversal Ultrasonics Used for In-Vivo Diagnostics of Human Skin under Tensile Loading

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Abstract

Human skin is from the anatomic view the largest organ protecting the body against external impacts. It exhibits relatively high tensile strength and elasticity at the same time, as well as nonlinear viscoelasticity and anisotropy. Ultrasonic wave propagation through the stratified human skin is an extremely complicated process influenced by many external factors such as mechanical loading and relaxation history, temperature, humidity, ultrasonic wave amplitude and frequency, etc. Spectral and nonlinear amplitude dependent characteristics of ultrasonic wave propagation may be used for medical diagnostics of relatively small skin elasticity changes. The noninvasive method has been proposed, based on guided wave propagation along the surface of forearm radial part. A small skin-loading device, equipped with suction cups with built-in ultrasonic transmitting and receiving probes is used to in-vivo skin studies. The device enables characterization of the skin behavior by temporal changes of ultrasonic wave propagation during repeated loading and stress relaxation periods. A special procedure of the precise signal arrival detection has been designed, and used for wave propagation velocity evaluation. Velocity, attenuation, and spectral changes are related to tensile test curves. Rheological model of the skin behavior is suggested, and its parameters are estimated. Nonlinear behavior is characterized using ultrasonic time reversal methodology. Rapid noninvasive ultrasonic evaluation of human skin in-vivo is useful in many dermatology applications such as surgery, medical treatment and also in cosmetics.

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Spectral properties of band random matrices over $\mathbb{C}$ and $\mathbb{H}$ division rings

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Abstract

The real band random matrices was investigated in detail last time. Spectra of these matrices are described by the spectral repulsion parameter $\beta \in \langle 0; 1 \rangle$. The formula for evalution of mentioned property is published in [4]. The complex band random matrices are introduced in [3], however the formula for enumeration the β parameter is not presented there.

In this report, the complex and the quaternion band random matices, abbreviated as CBRME and QBRME respectively, are introduced. The formula for β parameter has been derived by the Monte Carlo method and the non-linear regression method. We have shown that the β lies in $\langle 0; 2 \rangle$ and $\langle 0; 4 \rangle$ in case of CBRME and QBRME respectively. The Wigner's semicircle law has been generalized for these new matrix ensembles. In addition, the formula for the spectral rigidity, presented in [4], has been verified for CBRME and QBRME.

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Stochastic maximum principle for controlled diffusions on infinite horizon

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Abstract

In the presentation, the discounted stochastic control problem will be considered. This kind of problem is very popular and plentifully used in the domain of stochastic finance since it leads to maximizing the average discounted agent's utility. The approach to the solution here is the maximum principle (MP) which, in deterministic setting, was formulated in 1950s by the group of L.S.Pontryagin. The modern approach to the stochastic MP is based on the BSDE theory which provides an elegant and easy-to-handle tool to describe the adjoint (shadow price) processes to the control problem and to formulate the MP using the Hamiltonian function, see e.g. [2], [4] and many others. For diffusions with jumps, a necessary maximum principle on the finite time horizon was formulated by Tang and Li [3] whereas sufficient optimality conditions on finite time horizon were specified by Øksendal, Sulem and Framstad [1]. The proof of sufficient maximum principle for discounted control problem driven by the Wiener process can be found in [5] together with some examples of application. Furthermore we will discuse some possible extensions to ergodic control and optimal stopping problem.

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History of Traffic Research

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Abstract

B. D. Greenshields introduced probably the first method of securing accurate data on traffic behaviour by means of taking photos. All other traffic theories are derived from his observations, firstly shown to the public in 1933. Description of this photographic method and consequent method of collecting and tabulating data will be dealt with in presentation. Greenshields was also probably the first who tried to formulate the relation of speed and density and who studied the traffic capacity. This study in which selected data are analysed to secure a measure of the working capacity of two-lane roadway and the amount of vehicle time lost under varying degrees of congestion will be mentioned. The theory of motion of a line of vehicular, written by E. W. Montroll in 1969, will be next topic. A very important formula still used today in a slightly modified form is given in this theory. Finally, a cellular automaton model for freeway traffic conceived by K. Nagel and M. Schreckenberg will be mentioned.

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Geodetic curves on combined surfaces for acoustic emission crack detection

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Abstract

Localization of acoustic emission sources using geodetic curves on surfaces is described. We demonstrate a numerical solution of geodesic equations by the algorithms called Functional iterations and Newton-Raphson method and compare their performance, efficiency and time consuming properties together with other advantages and disadvantages. We deal with cylinders, spheres, cones, toruses and their combinations with various type of connected intersections. Such complex surfaces can be complicated for computationally practical purposes. The main task is to find the corresponding surface geodesics, which go through the points of intersections. For faster computation we propose a few improvements involving non-numerical solution of geodetic curves and using sequential algorithm applied to bisected points of the intersections. We present the geodesic solution for virtual testing body which was designed according to the real solid watering can.

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