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INTERNATIONAL CONFERENCE

MODERN STOCHASTICS: THEORY AND APPLICATIONS V

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DISCRETE APPROXIMATION OF CONTINUOUS DISTRIBUTIONS OBTAINED BY MINIMIZING THE WEIGHTED CRAMÉR-VON MISES DISTANCE

A. Barbiero[1], A. Hitaj[2]

We consider the problem of approximating a continuous probability distribution, characterized by a cumulative distribution function (cdf) $F(x)$, by means of k points $x_1 < x_2 < \cdots < x_k$, with probabilities p_i, $i = 1, \dots, k$. For measuring the accuracy of the approximation, we consider the weighted Cramér-von Mises distance between the original cdf $F(x)$ and the step-wise cdf $\hat{F}(x)$ of the approximating discrete distribution, defined as $G(\boldsymbol{\eta}) = \int_{-\infty}^{+\infty} g(x)[F(x) - \hat{F}(x;\boldsymbol{\eta})]^2 \mathrm{d}x$, with $g(x)$ a non-negative weighting function and $\boldsymbol{\eta}$ the vector gathering the x_i and p_i: $\boldsymbol{\eta} = [x_1, x_2, \dots, x_k, p_1, p_2, \dots, p_k]$. For a given k, the objective can be to find the k-point discrete distribution minimizing G. This problem was solved analytically by [1] when $g(x) = F'(x)$ and by [2] when $g(x)$ is a piecewise constant function, through a numerical iterative procedure based on a homotopy continuation approach. In this talk, we implement a solution to this problem highlighting how the results are affected by the choice of $g(x)$ and by the number of approximating points k; applications to several well-known continuous distributions and to a practical problem are also illustrated.

References

[1] Kennan, J., *A note on discrete approximations of continuous distributions.* Unpublished Manuscript, University of Wisconsin–Madison, 2006.

[2] Schrempf, O. C., Brunn, D., Hanebeck, U. D., *Dirac mixture density approximation based on minimization of the weighted Cramér-von Mises distance.* In 2006 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems, 512–517.

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APPLICATION OF STOCHASTIC DISCRETE AGE-OF-INFECTION EPIDEMIC MODEL FOR LENGTHY EPIDEMIC FORECASTING

Oleksandr Bogdanov

Today the problem of epidemic development is important due to the COVID-19 worldwide pandemic. In order to forecast the future number of new cases, suitable epidemic models that account for the long duration and change in the dynamics of the pandemic need to be developed. This would allow to estimate the future effect of the introduction of quarantine measures, or whether the vaccination of a limited number of people would cause a significant change.

The presented model is based on the work [1], which describes a stochastic epidemic model with discrete time and variable infectivity based on the age of infection. In this model the daily number of new cases follows the binomial distribution with one of its parameters depending on the number of cases in previous days. Such model has a number of advantages:

(1) It takes into account the change of the infectivity rate from the moment of infection to the recovery or death.
(2) The model is stochastic, which corresponds to the real nature of the pathogen transmission.
(3) The model is easy to use, with known formula for the maximum likelihood estimation of the parameter R_0 (basic reproduction number).

In this report an expanded version of the model is presented:

(1) The detection rate DR is introduced as an additional parameter. In the real scenarios some cases remain undetected either due to incomplete monitoring of the population or imperfect tests, and the model accounts for that.
(2) It is now possible to split the duration of the epidemic into several periods with different sets of parameters on each period. For example, this allows to account for the changes in the rate of transmission with the introduction or removal of quarantine measures.

In addition, a program was developed that allows to estimate the parameters R_0 and DR and simulate the development of the epidemic using existing statistic.

References

[1] Katriel, G., *Stochastic discrete-time age-of-infection epidemic models.* Int. J. Biomath. **6** (1), 2013, 1250066.

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