OPTIMAL PREVENTIVE STRATEGIES FOR SEIR TYPE MODEL OF THE 2014 EBOLA EPIDEMICS

Ellina Grigorieva[1] and Evgenii Khailov[2]

[1]Department of Mathematics and Computer Sciences
Texas Woman's University, Denton, TX 76204, USA

[2]Faculty of Computational Mathematics and Cybernetics
Moscow State Lomonosov University, Moscow, 119992, Russia

Abstract. A SEIR type model for the spread of Ebola epidemic in a population of constant size is considered. In order to control the spread of infection and prevent such epidemics, we add to the model four bounded controls. Three of them represent the efforts that reduce the contact between the susceptible and infectious individuals, between the susceptible and hospitalized, and, lastly, between susceptible and buried individuals. The fourth control represents the burial efforts. We state the optimal control problem of minimizing the number of the infectious individuals at the given terminal time. The corresponding optimal solutions are obtained with the use of the Pontryagin maximum principle. We establish that the optimal controls are bang-bang. Their types are investigated analytically. Our approach for estimating the number of zeros of the corresponding switching functions is novel. The resulting estimates enable us to reduce the original optimal control problem to a considerably simpler problem of the finite-dimensional constrained minimization. Results of the numerical solution are discussed.

Keywords. SEIR type model, control the spread of Ebola epidemic, nonlinear control system, Pontryagin maximum principle, non-autonomous quadratic differential system, generalized Rolle's theorem

AMS (MOS) subject classification: 49N90, 90C90, 93C95.

1 Introduction

The current 2014 West Africa Ebola epidemic is the largest outbreak on record. In less than a year it has killed over 4000 people. It has infected three countries – Guinea, Liberia, Sierra Leone, and it was also transmitted to Dallas, Texas, USA, where two healthcare providers were infected. The Ebola epidemic threatens public health with a high mortality rate and absence of licensed treatment and vaccines. Therefore, the practical control interventions of public health measures are major factors for stopping Ebola transmission. In West Africa, for example, the deceased people, who are not