Pest detection by inversion of a pheromone dispersion model

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Résumé

One third of the annual world's crop production is directly or indirectly damaged by insects. Early detection of invasive insect pests is key for optimal treatment before infestation. Existing detection devices are based on pheromone traps: attracting pheromones are released to lure insects into the traps, with the number of captures indicating the population levels. Promising new sensors are now available to directly detect pheromones produced by the pests themselves and dispersed in the environment. Tracing the source of pheromone emission would allow locating the pest's habitat and performing pesticide-free elimination treatments, in a precision agriculture context.

We formalized a 3D diffusion-convection model of pheromone concentration dispersion in the environment that include vegetation-dependant pheromone settling coefficients, in agreement with existing chemical transport models (1). This model is converted into a 2D reaction-diffusion-convection model after integration. A sensitivity analysis of this direct dispersion (forward) model is performed. An inverse (backward) model is then derived to identify the sources of pheromone emission from signals produced by sensors spatially positioned in the landscape. A priori biological knowledge on pest behaviour (favourite habitat, insect clustering for reproduction...) is introduced to constrain the inverse problem towards biologically relevant solutions. The accuracy of the inverse solution is assessed on simulated noisy data.

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(1) Stockie, J. M. (2011). The mathematics of atmospheric dispersion modeling. Siam Review, 53(2), 349-372

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