MODELING PESTICIDE APPLICATION RISKS USING AGRICULTURAL DRONES: A COMPUTATIONAL APPROACH

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Introduction. Agricultural drone technology, also known as UAVs or agrocopters, presents a transformative approach to crop treatment, distinct from conventional aerial and ground-based methods. This article examines the benefits of UAV crop treatment, focusing on the localized or point-specific treatment capabilities that distinguish agrocopters from traditional methods [1, c. 213].

Unlike ground-based sprayers that may struggle with hard-to-reach areas due to land configuration or chaotic land division, agrocopters offer precise, point-specific treatment. This enables efficient treatment of specific sections of a field, addressing issues such as underdeveloped areas or excessive weed growth [0, c. 6].

Precision agriculture aims to achieve the optimal distribution of pesticide solutions onto target areas for effective pest and disease control. UAVs contribute to this goal by minimizing chemical drift and reducing non-target exposure, ensuring more efficient resource utilization. Traditional crop treatment methods often result in significant chemical losses, estimated at 50–60%. Agrocopters, with their point-specific treatment capabilities, minimize these losses, leading to substantial economic savings for farmers [1, c. 213, 0, c. 19].

In order to assess risks for workers and the environment, the process of applying pesticides using an agricultural drone was simulated.

Materials and Methods. Mathematical models and computer simulations, grounded in fluid dynamics, serve as essential supplements to field trials, offering insights into the physical processes during droplet dispersion. Initial modeling of spray droplet movement employed atmospheric dispersion models, with the Gaussian plume model being the most prevalent. This model, effective for predicting pesticide concentrations at varying distances (0.5-10 km), simulates the transport of pollutants over medium to long distances, considering meteorological factors such as atmospheric stability [0, c. 284].

To enhance efficiency and reduce risks for workers and the environment, predicting the direction and radius of pesticide spread during drone applications is crucial. The first stage of our predictive model development involved analyzing the airflow around the agrocopter during operations, utilizing SolidWorks software for computer-aided design and simulation [0, c. 107].

Results. In our research, the development of a detailed 3D model for the agrocopter played a pivotal role in advancing our understanding of pesticide dispersion during aerial applications. This intricate model encapsulated the complete anatomy of the agrocopter, including its geometric structure, internal components, reservoir configurations for pesticides, and the spraying equipment employed. The significance of this 3D model lies in its multifaceted utility, enabling comprehensive simulations and analyses of various factors influencing pesticide distribution.

Results. The simulation capabilities of our model extend beyond mere visualization; they allow us to delve into the dynamics of agrocopter movement during operations. By incorporating real-world variables and conditions, we gain insights into how the agrocopter interacts with the environment during pesticide application. This encompasses factors such as wind speed, direction, flight height above crops, and the quantity of the working solution used in each treatment.

Furthermore, the model empowers us to identify and analyze optimal parameters that significantly impact spraying efficiency. Parameters such as the agrocopter's height above the crops, its speed, the tilt angle of the nozzles, and other operational variables can be systematically varied and studied. This detailed analysis aids in determining the most effective and efficient application strategies, contributing to the overall precision and success of pesticide treatments.

Our model also serves as a powerful tool for generating visual representations of pesticide dispersion. These visualizations offer a tangible way to comprehend the intricate patterns and dynamics of chemical distribution during aerial applications. This not only aids researchers in interpreting the simulation results but also facilitates effective communication of findings to stakeholders and industry professionals.

However, it's essential to acknowledge that our ongoing research, while providing valuable insights, represents just a step towards the development of comprehensive computer modeling for predicting pesticide drift. The complexity of environmental factors, the variability in real-world conditions, and the need for a more nuanced understanding of interactions between the agrocopter and the surrounding environment underscore the necessity for more specialized software. Continued efforts in research and development will be crucial for refining these models and advancing their capabilities for accurate and predictive analyses of pesticide dispersion in agricultural drone applications.

In **conclusion**, our research on the dispersion of pesticides through aerial applications using agrocopters represents a significant stride towards advancing precision agriculture practices. The creation of a detailed 3D model for the agrocopter has proven instrumental in enhancing our understanding of pesticide distribution dynamics. The model's versatility allows for realistic simulations that consider various environmental factors, operational parameters, and their collective impact on spraying efficiency.

The insights gained from our simulations extend to the optimization of key parameters, including flight height, speed, and nozzle tilt angle. This optimization process contributes to the development of more effective and efficient pesticide application strategies. Visual representations generated by the model offer a tangible means of interpreting complex dispersion patterns, aiding researchers and industry professionals alike in comprehending the intricacies of chemical distribution during aerial operations.

While our research provides valuable insights, it is important to acknowledge that it represents an initial step in the broader endeavor of developing comprehensive computer models for predicting pesticide drift. The ongoing complexity of real-world conditions necessitates further refinement and specialization of software tools. Future research endeavors will focus on addressing these complexities to ensure the accuracy and predictive capabilities of our models in diverse agricultural settings.

As agriculture continues to embrace technological innovations, the integration of precise aerial applications facilitated by agrocopters holds immense promise for sustainable and efficient crop management. The findings from our research contribute to the ongoing dialogue surrounding the responsible and effective use of unmanned aerial systems in agriculture, paving the way for advancements in precision agriculture and environmental stewardship.

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ПОЄДНАННЯ СПОСОБУ ЖИТТЯ ТА ДИСТАНЦІЙНОЇ ФОРМИ НАВЧАННЯ

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Інформаційно-телекомунікаційні технології відкрили широкі перспективи учасникам освітнього процесу. Важливим елементом сучасної освіти є глобальна співпраця, доступність до світових інформаційних ресурсів та можливість онлайн-навчання. Сьогодні досить легко візуалізувати необхідну інформацію що значно полегшує процес оволодіння необхідними знаннями [1]. Можливість використання каталогів електронних бібліотек, різноманітних навчально-методичних розробок, презентацій, смарт додатків, онлайн-курсів та інших