STATISTICAL-MATHEMATICAL MODELS AND SMART AGRICULTURE TOOLS, THEIR APPLICATION IN THE DESCRIPTION AND MANAGEMENT OF AGRICULTURAL PROCESSES

MODELOS ESTADÍSTICOS-MATEMÁTICOS Y HERRAMIENTAS DE AGRICULTURA INTELIGENTE, SU APLICACIÓN EN LA DESCRIPCIÓN Y GESTIÓN DE PROCESOS AGRARIOS

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Abstract

The professionals of Basic Sciences and Computer Science of the Scientific Teaching Complex (UNAH-CENSA-INCA-ICA), in their role of research, training and social leadership, assume the development of Agricultural research associated with Statistical-Mathematical Modeling, Process Simulation and the use of Smart Agriculture tools, aimed at making optimal decisions. The objective of this work is to show the results achieved by the Multidisciplinary group in these topics, as well as the research and training strategies of the Master in Biomathematics (Accredited Program of Excellence). Background and work developed for more than forty years is shown in Statistical Methodologies and software specialized in studies of animal and plant growth processes, pest behavior, lactation curves, genetic improvement, as well as in the integration of different sources. of data and methods for carrying out intelligent queries in a Geographic Information System, among others. Current research challenges are addressed, associated with the theoretical selection of neural networks as an artificial intelligence method to be used to predict the incidence of pests in different crops; the use of Smart Agriculture tools applied to livestock at the University-Farm-Guayabal and DSSAT Crop Simulation Models (corn), among other topics anchored to a Project of the National Program of Basic and Biological Sciences (PNCB 2024-2026) . It is concluded that multidisciplinary work, from the management of Basic and Computer Sciences, allows qualitative leaps and addresses the challenges and development of society.

Keywords: Mathematical Modeling, Artificial intelligence, Process Simulation

Resumen

Los profesionales de las Ciencias Básicas e Informáticas del Complejo Científico Docente (UNAH-CENSA-INCA-ICA), en su rol de investigación, capacitación y liderazgo social, asumen el desarrollo de investigaciones Agrarias asociadas a la Modelación Estadístico-Matemática, Simulación de Procesos y al empleo de herramientas de Agricultura Inteligente, encaminadas a la toma de decisiones óptimas. El presente trabajo tiene como objetivo mostrar los resultados alcanzados por el grupo Multidisciplinario en estas temáticas, así como las estrategias de investigación y de formación de Master en Biomatemática (Programa acreditado de excelencia). Se muestran antecedentes y el trabajo desarrollado por más de cuarenta años, en Metodologías Estadísticas y software especializados en estudios de procesos de crecimiento animal y vegetal, en comportamientos de plagas, curvas de lactancia, mejoramiento genético, así como, en la integración de distintas fuentes de datos y métodos para la realización de consultas inteligentes en un Sistema de Información Geográfica, entre otras. Se abordan retos actuales de investigación, asociados a la selección teórica de las redes neuronales como método de inteligencia artificial a emplear para el pronóstico de la incidencia de plagas en diferentes cultivos; el empleo de herramientas de Agricultura Inteligente aplicadas a la ganadería en la Universidad-Granja-Guayabal y Modelos de Simulación de cultivos (maíz) DSSAT, entre otros temas anclados a un Proyecto del Programa Nacional de Ciencias Básicas y Biológicas (PNCB 2024-2026). Se concluye que el trabajo multidisciplinario, desde la gestión de las Ciencias Básicas e Informáticas, permiten saltos cualitativos y hacen frente a los desafíos, retos y desarrollo de la sociedad.

Palabras claves: Modelación Matemática, Inteligencia Artificial, Simulación de Procesos

Introduction

Generally, in the Agricultural sector, Universities, production and research centers request the collaboration of mathematicians, physicists, computer scientists and related experts for the efficient development of their research projects, as well as for data processing and analysis and search. of optimal solutions and productions.

The professionals who take on these challenges require the development of new models, algorithms and a constant update in advanced statistical - mathematical procedures, work methodologies, specialized software and smart agriculture tools, the use of which favors analysis and decision making. and the results of the production and innovation processes carried out.

For this reason, from 1994 to the present, the Agrarian University of Havana (UNAH), focuses and develops the research line "Applied Mathematics and Informatics", which includes sublines such as: Process Modeling and Simulation, Agrophysics and Agricultural Geoinformatics, and Applied Informatics. to Agrarian Systems, which have been linked to related National and International Research Projects and contemplate different Agrarian Processes. The objective of this Work is to disseminate some experiences and results achieved by the Biomathematics group of the Scientific Teaching Complex (UNAH-CENSA-INCA-ICA) in research, in Master's training in Biomathematics and scientific - teaching - research activity.

Development

The biomathematics research group
(UNAH-INCA-CENSA-ICA)

The Agrarian University of Havana is the governing center for the majority of agricultural careers in Cuba and its strength is to be part of a Scientific-Teaching-Productive Complex that responds to different Agricultural Processes in the areas of Animal Production, Science Agriculture and Agricultural Health among other real life phenomena.

The Biomathematics research group of this Scientific-Teaching complex for more than 40 years, assumes challenges and growing demands in the area of Applied Mathematics and Informatics, with relevant results in research, training, Master's training in Biomathematics and doctors. in Sciences in the Agricultural sector.

Background and associated research

The research developed and results achieved are part of a cluster of National and International Research Projects developed and led by the group. Some of these research topics developed are shown in chronological order (start date), such as:

Mathematical Modeling of agricultural and biological processes related to linear and non-linear models of weight growth of plants and animals (related to sigmoidal models), (1996).

Mathematical Modeling through differential equations and Linear Programming, linked to research on the optimization of agricultural machinery, crop rotation among other processes and Probabilistic Modeling to investigate the behavior of pests and other processes (1996).

Simulation models and power analysis in Variance Analysis Models (1998; 2000). As well as the techniques of Multivariate Statistics in Agricultural Sciences, (1996), among other topics.

Behavior of the pest introduced in Cuba, Thrips palmi Karny (Thysanoptera: Thripidae) in potato cultivation and other aspects of quantitative ecology (2002, 2003 and 2008).

Genetic evaluations and improvements in cattle (with the use of the BLUP Animal Model and the use of weighing on the control day), random regression models are incorporated for the estimation of genetic parameters, (2008; 2011, 2012).

Statistical-Mathematical Modeling of categorical and mixed variables, Categorical Regression (CATREG) and Categorical Principal Component Analysis (CATPCA), where joint research was carried out on the production-marketing system of goat-sheep in La Guajira, Colombia, as well as also in the sustainability of Cuban livestock companies in the west of the country. Alternative analysis procedures with discrete and categorical variables were included in agricultural research (2010, 2014, 2016).

Stochastic linear modeling for flow forecasting in the basin, western region of Cuba and for flood prevention in the agricultural area of Cuyaguateje. (2016, 2018)

Use of time series and autoregressive Integrated Moving Average (ARIMA) models for syndromic surveillance in piglets. Includes work methodology (2019).

DSSAT MODEL Use of the Agrotechnology Transfer Decision Support System (DSSAT) to estimate the optimal dose of nitrogen fertilizer for the J-104 rice variety and the DSSAT-CROPGRO model in management strategies for soybeans (2018, 2019) .

Response Surface Methodology (MSR) in sugar cane, citrus, grass and forage crops (to determine optimal fertilization conditions), and in Agricultural Technical Sciences (in the evaluation of the optimal functioning of the internal combustion engine at use diesel-ethanol mixtures). (2019).

Mathematical modeling of the population fluctuation of Thrips (Insecta: Thysanoptera) in Solanum tuberosum L. (2022).

Integration of different data sources and Method for carrying out intelligent queries in a Geographic Information System (2022).

Some of these results have been reported by: Fernández, L et al (2011, 2019); Jiménez, Y et al (2012); Vázquez, Y (2014); Miranda, I et al (2016); Rivero, A et al (2018); Guerra, W. (2019); Fernández Liansy et al (2020); Herrera, M et al (2020); Rodríguez, O et al (2020); Del Pozo et al (2021), González, J et al (2022); among others.

Introduction and generalization of results (knowledge transfer)

The results achieved in these topics, together with a high demand for professionals in the agricultural sector who require solid knowledge in advanced Statistical Methods and work methodologies, led the Biomathematics group to draw up a group of actions for the introduction of results, which included:

• Update postgraduate, specialty, Master's and doctoral course programs that are developed in the complex, which include the knowledge, models and work methodology achieved.
• Design theoretical-practical courses, which include current problems associated with each specialty.
• Achieve correspondence between mathematical-biological language in each course.
• Provide advice to undergraduate, master's and/or doctoral theses that require the use of new statistical tools and procedures.
• In other aspects

The methodologies that are part of these and other investigations are introduced and generalized in undergraduate and graduate teaching, which has contributed to teaching and scientific-research development in the Basic Sciences. Likewise, it achieves the transfer of knowledge in the network of national universities and research centers, mainly in the Agricultural sector, and in foreign universities such as: ARGENTINA (National University of Lomas de Zamora (UNLZ), University of Buenos Aires (UBA), BRAZIL (Paulista State University (UNESP), COLOMBIA (Universidad de la Guajira), SPAIN (University of Granada, University of Zaragoza, University

of Alicante), ECUADOR (Amazonian State University (UEA), Agrarian University of Ecuador (UAE), University of Loja , Santa Elena Peninsula State University (UPSE)).

Master training in biomathematics

The different research and training strategies in the area of Applied Mathematics and Computing focus fundamentally on the MASTER'S DEGREE IN BIOMATHEMATICS, now in its fourth edition and accredited by the National Accreditation Board (JAN, 2021) as a PROGRAM OF EXCELLENCE. This master's degree responds to research projects from different centers and currently coordinates two of them.

1. Guayabal University-Farm integration project, entitled "Basic and computer sciences facing technological and scientific challenges at UNAH" (2021-2024), is a project aimed at developing the technological-scientific-teaching-productive scenario of Cuban agriculture at the Guayabal University Farm, focused on University-business integration and aimed at achieving research spaces, sustainable production and obtaining a greater amount of healthy food with benefits for students, the scientific community and their environment.

2. Project of the National Program of Basic and Natural Sciences, entitled "Development of Statistical-Mathematical Models and tools of Intelligent Agriculture, for their application in the description and management of Agricultural Processes". (PN223LH010-066., period 2024-2026), whose general objective is aimed at developing new knowledge necessary for the application of Statistical-Mathematical Models, the Simulation of Agricultural Processes and Smart Agriculture tools to the description and management of Agricultural Processes for making optimal decisions.

Part of the results of these projects focus on the development of new research topics, such as:

1. Obtaining forecast models that use artificial intelligence to create computer tools that facilitate decision-making regarding the management of agricultural pests.

2. Obtain the Mathematical Model that best describes Agricultural Processes under the new experimental conditions, as well as optimization models that allow optimal decision making.

3. Apply Smart Agriculture tools (DSSAT simulation models in the cultivation of basic grains and in control of livestock indicators) for the efficient management of agricultural information in the Scientific Complex, including the technological-scientific-teaching-productive scenario. Agrarian University - Guayabal company

The high correspondence of the research that is addressed with the current social needs and perspectives of the territory, the country and other countries is highlighted, which constitutes a permanent challenge in the area of Applied Mathematics, for this group of specialists and which maintains as constant perspective:

- Develop new research strategies with a view to increasing the results achieved
- Generate new concepts, models and work methodology that respond to new problems in the agricultural and related sectors.
- Strengthen cooperation and knowledge transfer
- Continue with the Generalization of results in Master's and doctoral programs that are developed nationally and internationally.
- Contribute to greater visibility and prestige of Basic Sciences, by increasing the number of scientific publications in national and international journals
- Strengthen the training of young professions such as a master's degree in Biomathematics (developed at the Agrarian University of Havana), and obtain competent specialists who respond to the teaching and scientific-research challenges of the new University.

The guarantee of quality in the development, introduction and generalization of each result lies in the multidisciplinary work, which brings together biomathematical experts from the Scientific Teaching Complex (UNAH-ICA-CENSA-INCA) who, together with other specialists, will carry out joint activities and strategies. of research that allow responding to research projects and postgraduate training, which fulfill their role in the development of the country

Conclusions

The integration of Basic and Computer Sciences into Research Projects, the teaching of Statistics courses (with theoretical-practical approaches and specialized software) and the transfer of knowledge of Statistical-Mathematical methodologies, allows qualitative leaps in Higher Education, raises the quality of Scientific Research and achieves competent specialists who respond to the challenges of the New Society.

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