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BIRD'S-EYE VISUALIZATION OF DESIGN-KNOWLEDGE DIVERSITY FOR LAUNCH VEHICLE IN VIEW OF FUELS ON HYBRID ROCKET ENGINE

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Single-stage rockets have been being researched and developed for the scientific observations and the experiments of high-altitude zero-gravity condition. The launch vehicle with hybrid rocket engine using solid fuel and liquid oxidizer has been being researched and developed as an innovative technology. The present study will investigate the conceptual design in order to develop a next-generation single-stage launch vehicle with hybrid rocket engine. In the present study, a single-stage launch vehicle with hybrid rocket engine of solid fuel and liquid oxidizer for the scientific observation of aurora will be conceptually designed by using design informatics approach in order to quantitatively reveal the advantage and in order to discover the fundamental physics regarding hybrid rocket engine.

Design informatics is essential for practical design problems. The set of optimal solutions produced by an evolutionary multiobjective optimization algorithm for multidiscipline can be considered a hypothetical design database for design space. Then, data mining techniques can be applied to this hypothetical database in order to acquire not only useful design knowledge but also the structurization and visualization of design space for the conception support of basic design. Three objective functions are defined in the present study. First objective is the maximization of the down range in the lower thermosphere (altitude of 90 to 150km) R_d [km] (obj1). Second is the maximization of the duration time in the lower thermosphere T_d [sec] (obj2). It recently turns out that atmosphere has furious and intricate motion in the lower thermosphere due to the energy injection, which leads aurora, from high altitude. The view of these objective functions are to secure the

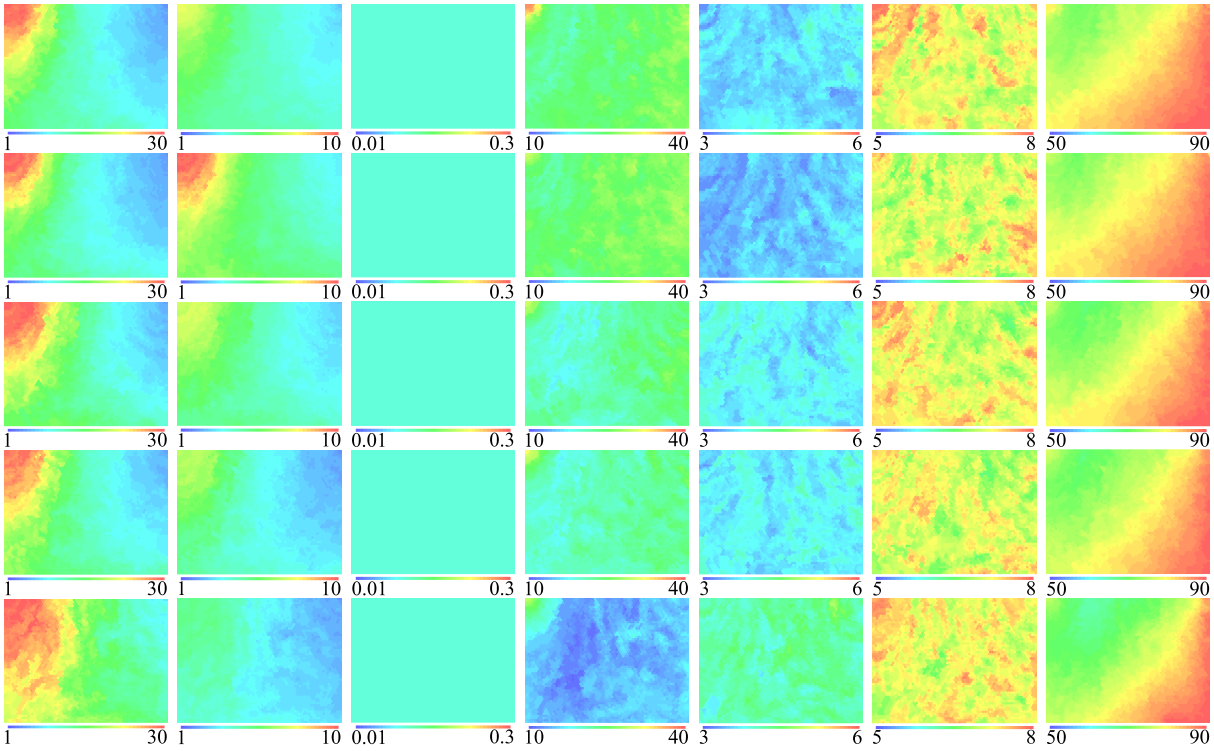

Figure 1: SOMs colored by the design variables. The color range is set to be their upper/lower values in the problem definition. The column means dv1, dv2, $\cdots$, and dv7 from the left. The row describes polypropylene, WAX FT0070, WAX PW120, GAP50PEG50, and GAP60PEG40 from the top.

horizontal distance and time for the competent observation of atmospheric temperature and the wind for the elucidation of atmospheric dynamics and the balance of thermal energy. Third objective is the minimization of the initial gross weight of launch vehicle $M_{\mathrm{tot}}(0)$ [kg] (obj3), which is generally the primary proposition for space transportation system. Trajectory, thrust, aerodynamic, and structural analyses are performed for the evaluation of objective functions.

In the present study, liquid oxygen as liquid oxidizer and five solid fuels are used as thermoplastic resin polypropylene, two WAXes (FT0070 and PW120), and two compounds between glycidyl azide polymer and polyethylene glycol (GAP50PEG50 and GAP60PEG40, the number means the blend proportion) for solid fuel in order to compare the implications of fuels in the performance of hybrid rocket.

The colored SOMs reveal the qualitative correlation among the objective functions and the difference of the behavior in the design space regarding the design variables. Figure 1 reveals that wax FT0070 and GAP60PEG40 have meaningful distinctions for the behavior of design variables.

Consequently, the design variables which obtains the implications of fuels have been revealed. Moreover, the influence of fuels for the behaviors of the objective functions and design variables has been evident.