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学术论文

Shape-Adaptive Ternary-Gaussian Model: Modeling Pointing Uncertainty for Moving Targets of Arbitrary Shapes

形状自适应的“三高斯”模型：任意形状的移动目标选择不确定性建模

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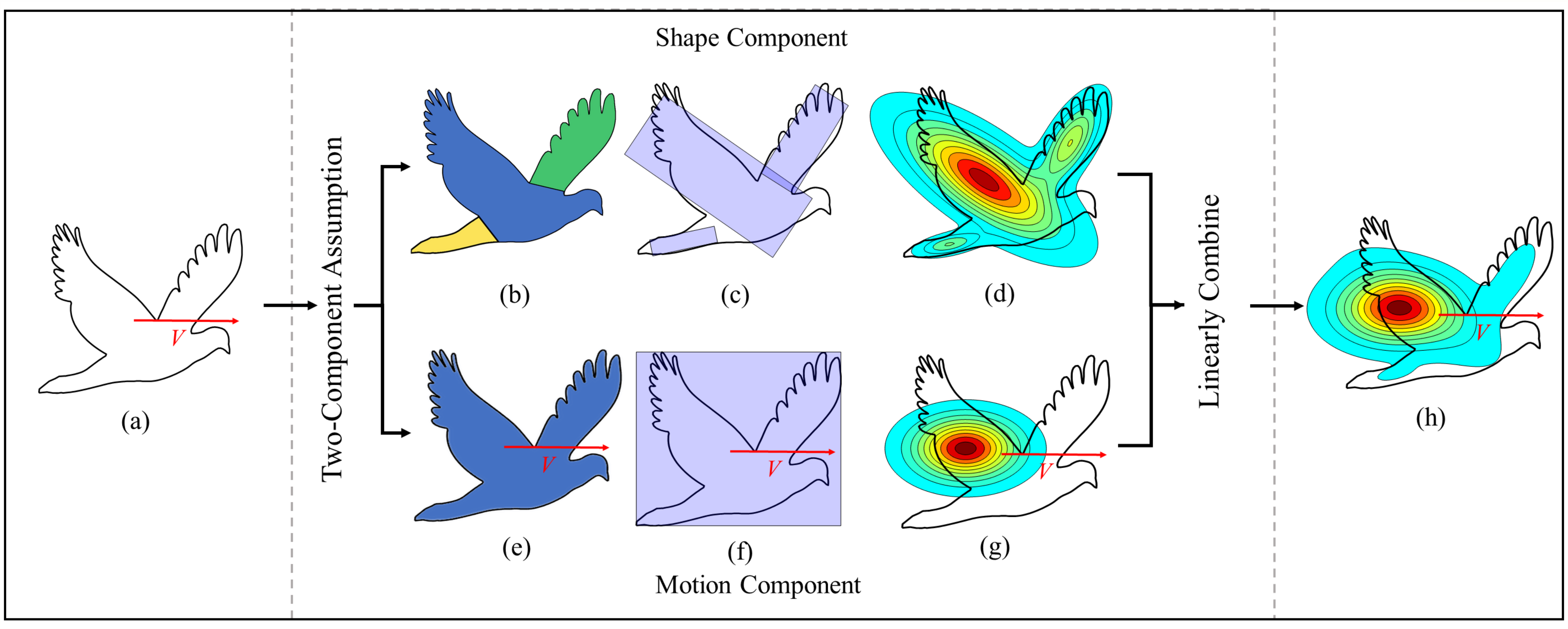

Fig 1. Shape-Adaptive Ternary-Gaussian Model

For user interfaces with moving targets such as games and video surveillance systems, targets could have different shapes, which is likely to have an impact on pointing uncertainty. Understanding such endpoint distributions is important because they can determine the selection error rate and partly affect movement time. However, there are few attempts to model endpoint distributions for moving targets with specific considerations of the target shape.

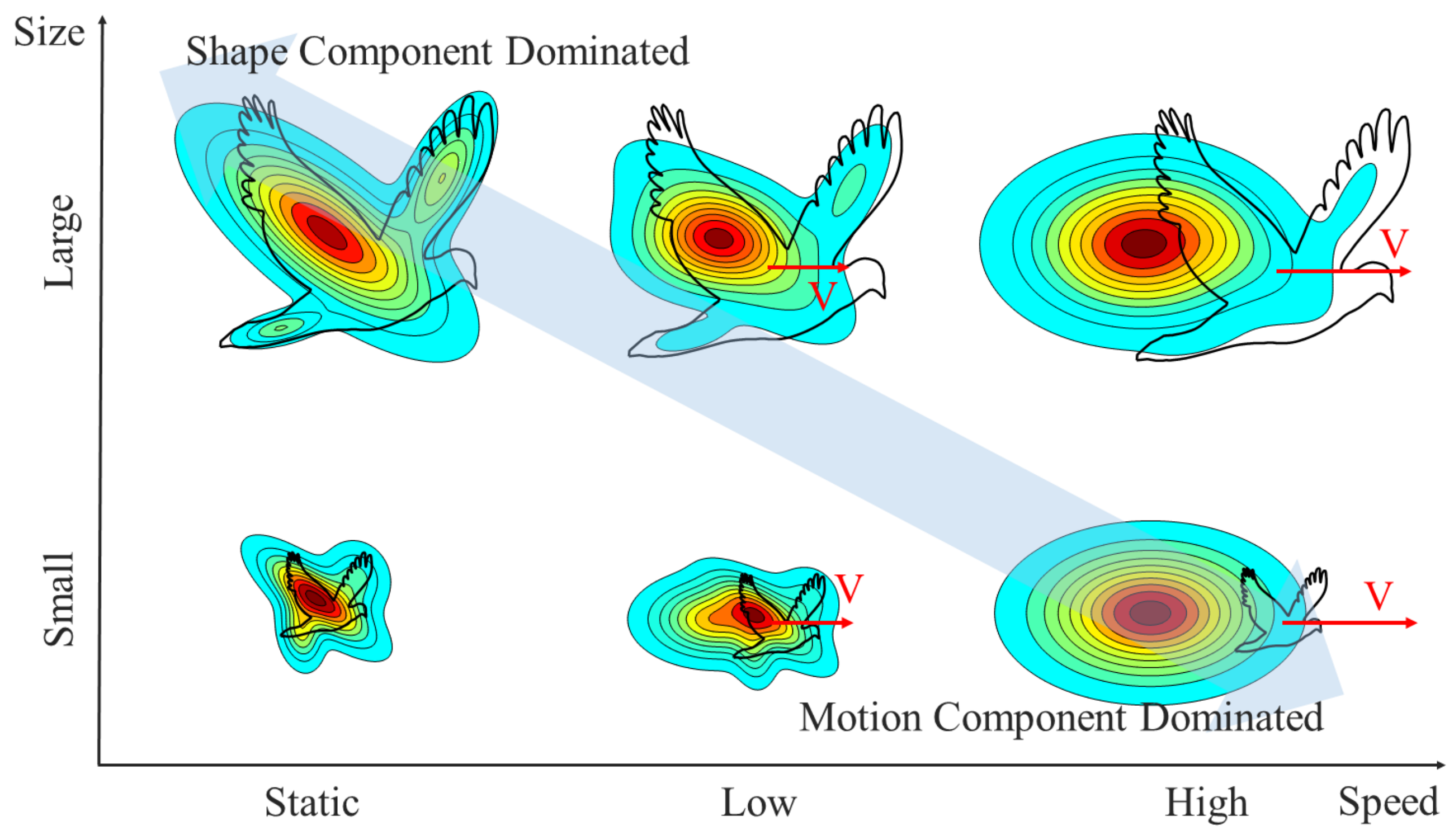

Fig 2. Two-Component assumption

We proposed a model to predict pointing uncertainty for arbitrary shapes based on a Two-Component assumption **(Fig. 1).** We assumed that the pointing uncertainty of moving targets of arbitrary shapes is a combination of one associated with shape and another caused by motion. When a target is large, stationary, or moving at lower speeds, users tend to optimize their pointing strategy by aiming at different parts of the target to increase their chances of hitting it. When the target is small or fast-moving, users need to adjust their vision and movement to keep up with it. To do so, they often reduce their focus on target features that are not relevant to its motion.

Specifically, for the shape component, we propose a DUDE-based model to account for the pointing uncertainty of target shape. For the motion component, we build a 2D Ternary-Gaussian model with the bounding box size of the shape that accounts for the pointing uncertainty of target motion. Finally, we linearly combined the Ternary-Gaussian model with the DUDE-based model to make the Ternary-Gaussian model adaptable to moving targets with random shapes (Fig. 1).

We evaluated our model with three studies. The apparatus, task setting and the ten target shapes used in the studies is shown in **Fig 3**.

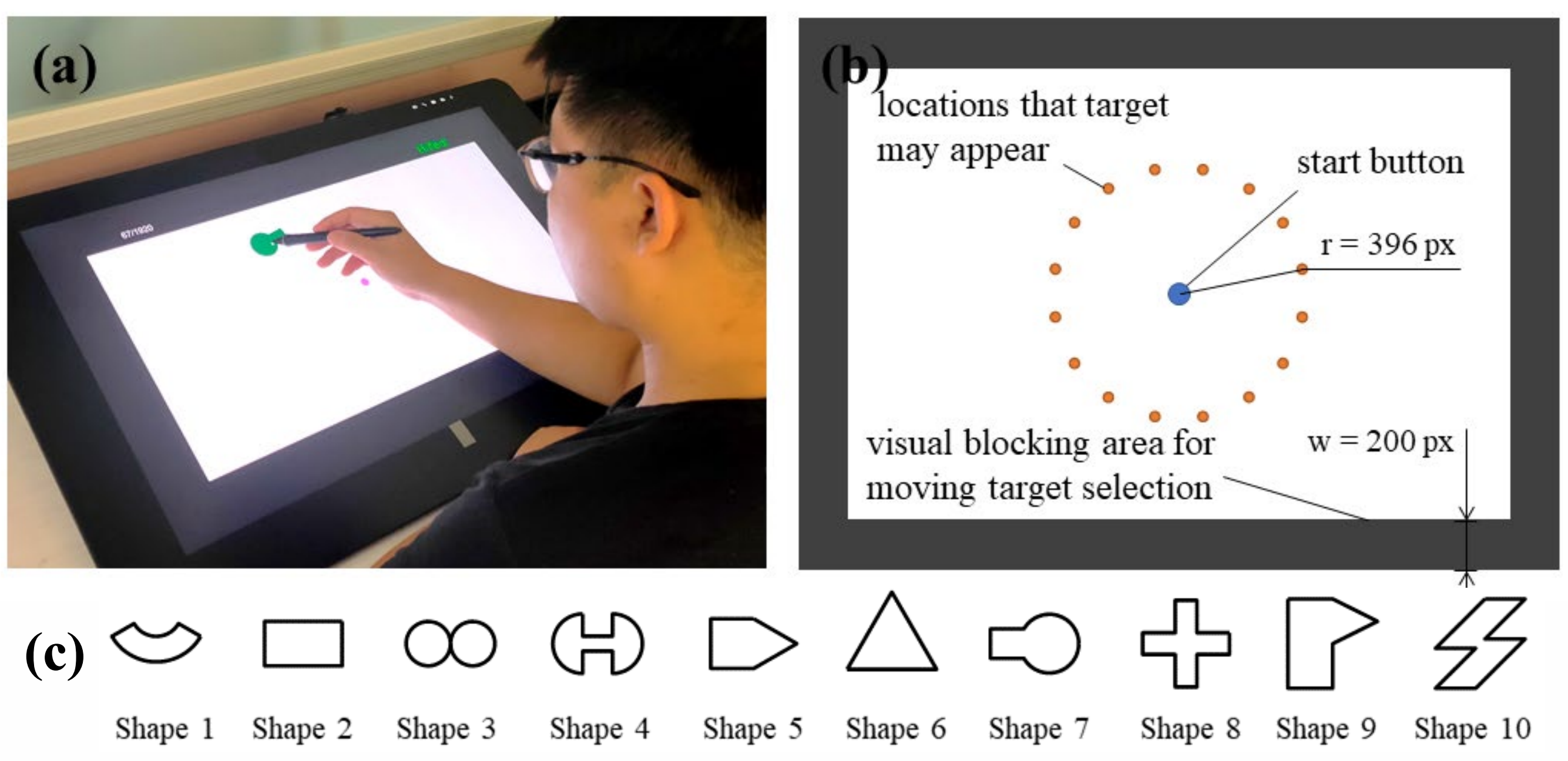

Fig 3. Apparatus and Task Setting

The results in Study 1 show that the DUDE-based model outperforms both two baselines models in describing shapes, as evidenced by smaller Hellinger Distance between the predicted and the actual endpoint distributions (**Fig. 4**).

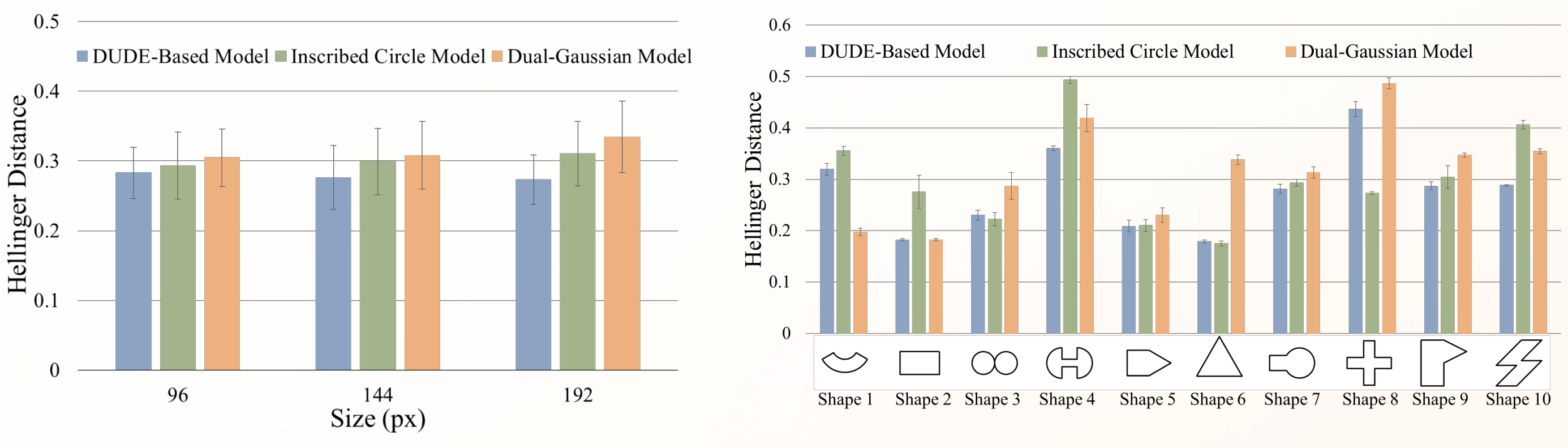

Fig 4. Performance of the DUDE-based model

Study 2 show that the overall Shape-Adaptive Ternary-Gaussian model outperforms both two baseline models in predicting endpoints distributions for moving target shapes (**Fig. 5**).

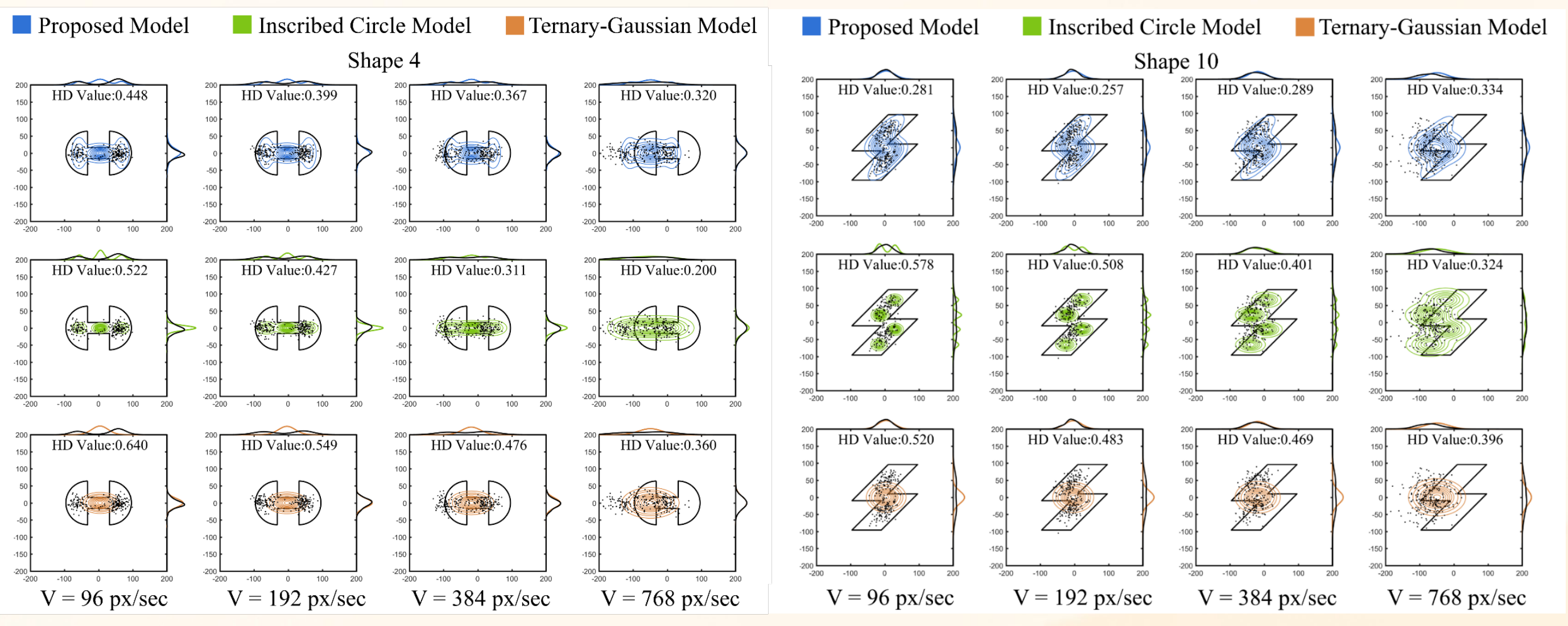

Fig 5. A sample of the endpoints distributions predicted by the three models

In Study 3 we re-recruited participants and changed the experimental design to further evaluate the robustness of our proposed model. The two additional experiments yielded similar results with Study 2 (**Fig. 6**).

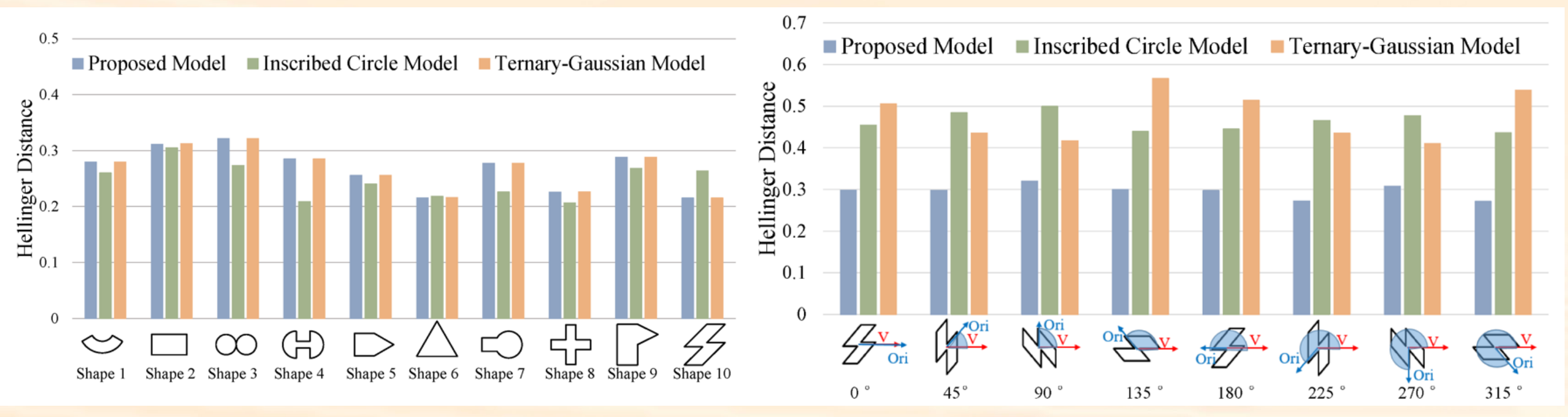

Fig 6. Further evaluation of our proposed model

We conclude with implications derived from this study for future designs and advances our understanding of how users perceive and interact with moving targets of arbitrary shapes.