Dynamics-Aware Trajectory Generation for Artistic Painting using Diffusion

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Introduction

Robot art is…
- challenging (dexterity, precision, etc),
- relevant (collaborative, HRI)
- meaningful (outreach, emotion)

A bridge among robots, creators, and consumers

GenAI for images (e.g. DALL-E)…
is great, but lacks *embodiment*. How to bring GenAI art to life?

DDPM for trajectory generation…
has been demonstrated by Diffuser, Diffusion Policy, etc.

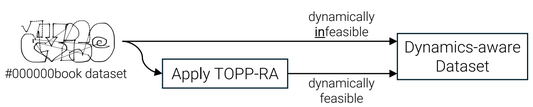
Why not motion planning *after* DDPM?
Art should leverage the unique qualities of the medium, so the composition should reflect the robot's capabilities.

Can DDPM help us generate robot trajectories for artistic painting?

Approach

Base DDPM
Based on Diffuser and SketchKnitter: U-Net 1D w/ FiLM, $[x, y, dx, dy, PenUp]$

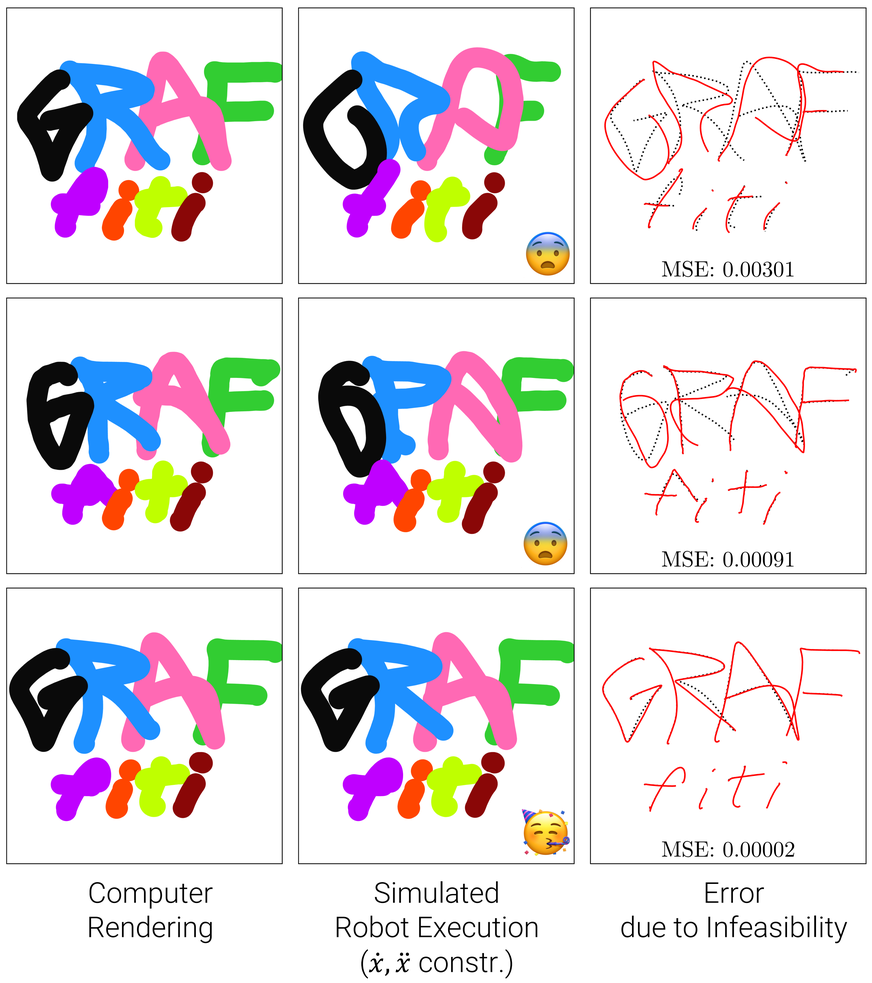
Training Data
#000000book – 73k graffiti drawings
Adapt using TOPP-RA to make strokes dynamically feasible



Infusing Dynamics
Found classifier-free guidance is best

Sample Result

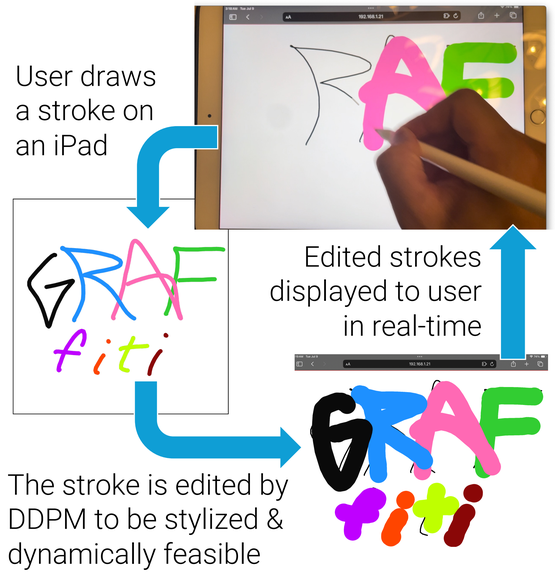
Drawings look good on the computer,
but if we execute them on a robot…
they look totally different!



The problem: humans are bad at giving dynamically feasible trajectories for a robot to paint
The solution: edit the trajectories to be dynamically feasible, while retaining graffiti "style"

Interactive Assist

(Sample Application)



Real-time, interactive editing helps the artist anticipate how the robot will move, plan their composition, and learn how to better accommodate the robot.

Conclusion

Coupling artistic generation with motion planning accentuates the robot in the art. Conditioning *Diffuser* on robot dynamics achieves dynamically feasible artistic motion generation specific to the robot.

Select References

[Diffuser]: Michael Janner, Yilun Du, Joshua Tenenbaum, and Sergey Levine. *Planning with diffusion for flexible behavior synthesis*. ICML (2022).
[SketchKnitter]: Qiang Wang, Haoge Deng, Yonggang Qi, Da Li, and Yi-Zhe Song. *SketchKnitter: Vectorized sketch generation with diffusion models*. ILCR (2023).
[TOPP-RA]: Hung Pham and Quang-Cuong Pham. *A new approach to Time-Optimal Path Parameterization based on Reachability Analysis*. T-RO (2018).