Learning Neurosymbolic Generative Models via Program Synthesis
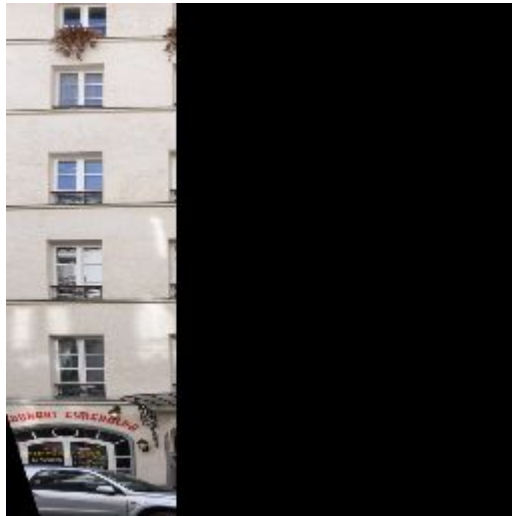
Halley Young, Osbert Bastani, Mayur Naik

University of Pennsylvania

Generative Models and Global Structure

Full Image

⅓ of Image
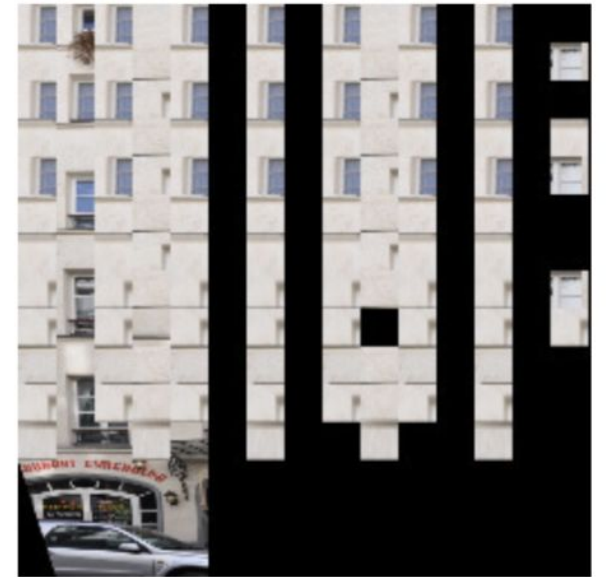

Baseline Completion

Our Approach: Global Structure as Programs


```
                            . . .
        for i = 1..3
            for j = 1..6
                draw(i*2, j*2,    )
                            . . .
```
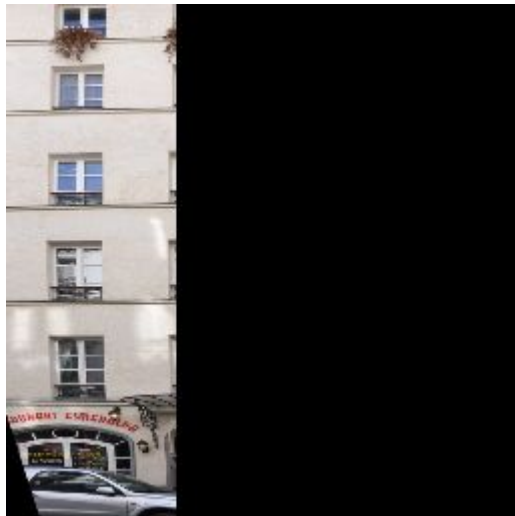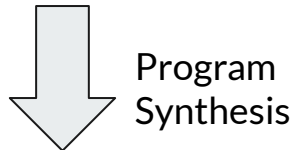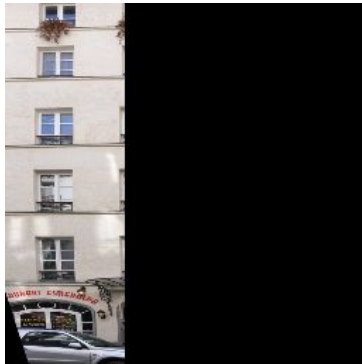
Application to Image Completion

Full Image

Third Image

Baseline Completion
(No representation of global structure)

Our Completion

Learning via Program Synthesis - Phase 1

Program
Synthesis

```
    ■ ■ ■
  for i = 1..3
    for j = 1..1                    }
      draw(i*2, j*1,  ▯  )
    ■ ■ ■
```
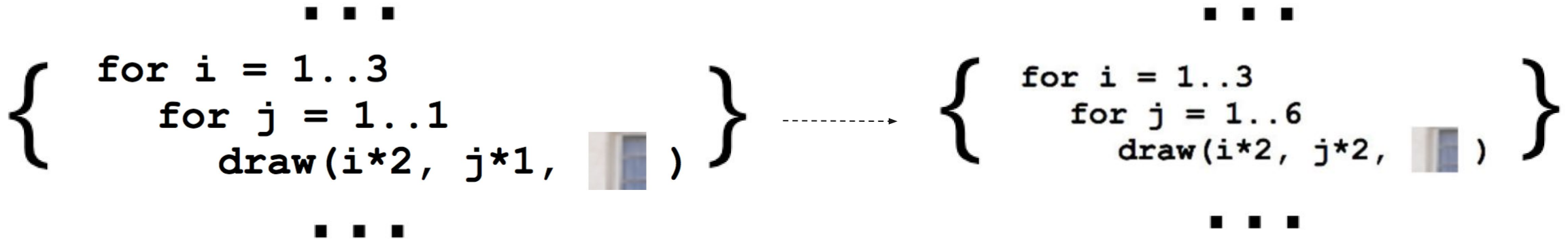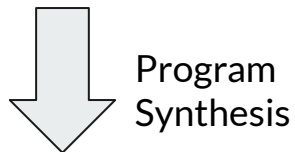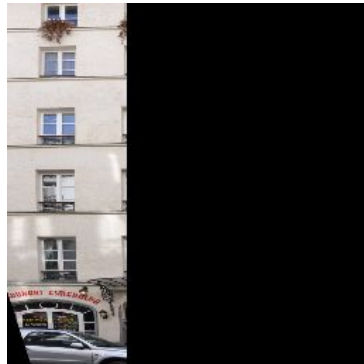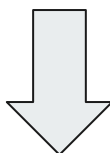
Learning via Program Synthesis - Phase 1
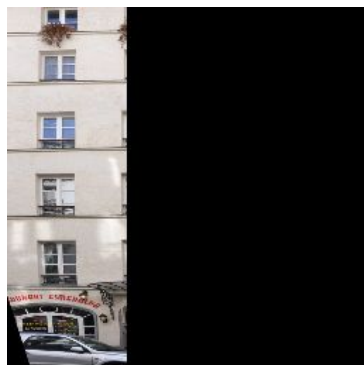
Program
Synthesis

```
{   for i = 1..3
        for j = 1..1
            draw(i*2, j*1,  ■  )   }
```
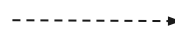
```
{   for i = 1..3
        for j = 1..6
            draw(i*2, j*2,  ■  )   }
```

Learning via Program Synthesis - Phase 1

Program Synthesis

Structure Rendering

```
{   for i = 1..3
        for j = 1..1
            draw(i*2, j*1,  )  }
```
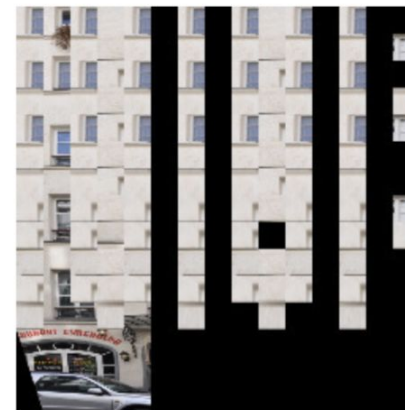
```
{   for i = 1..3
        for j = 1..6
            draw(i*2, j*2,  )  }
```
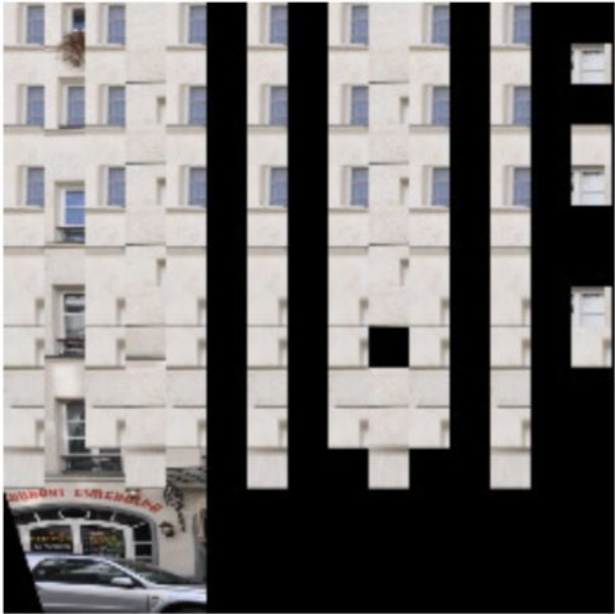
Learning via Program Synthesis - Phase 2

Comparison to Baselines

Model	Synthetic		Facades	
	SGM	BL	SGM	BL
GLCIC	**106.8**	163.66	**141.8**	195.9
CycleGAN	**91.8**	218.7	**124.4**	251.4
VED	**44570.4**	52442.9	8755.4	**8636.3**

Our approach (Synthesis-Guided Generative Model, SGM) significantly **outperforms the baseline in 5 out of 6 experiments** in image completion (as well as in all image generation experiments).

(Scores for GLCIC/CycleGAN represent Fréchet Inception Distance, scores for VED represent negative log likelihood).
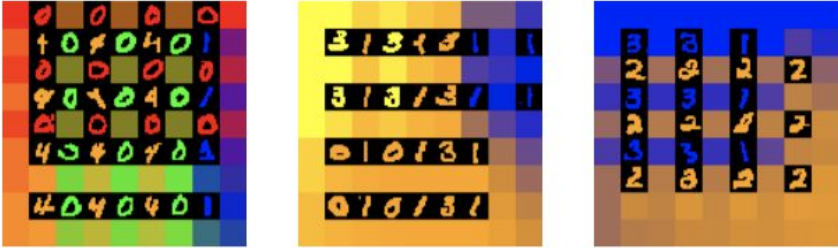
Experimental Results

Original Image (Synthetic)
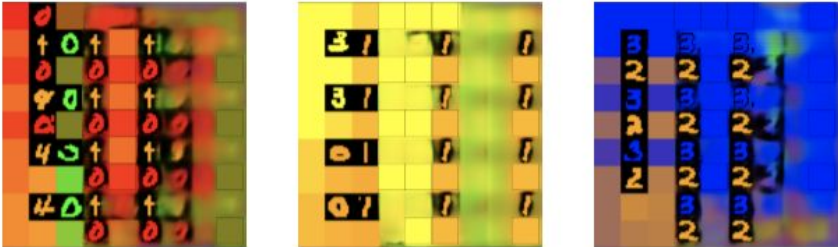

Original Image (Facades)

Experimental Results

Original Image (Synthetic)
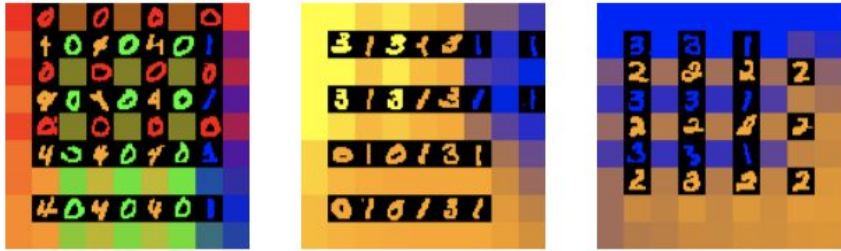
Original Image (Facades)

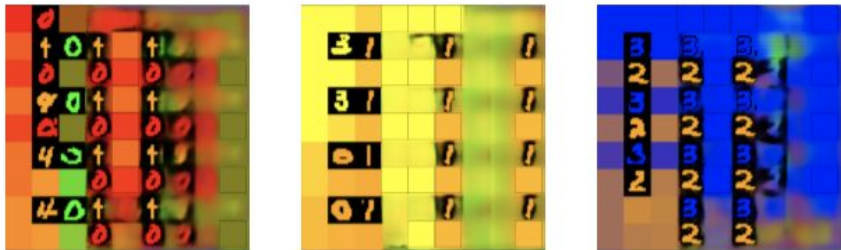SGM (GLCIC, Synthetic)

SGM (GLCIC, Facades)

Experimental Results
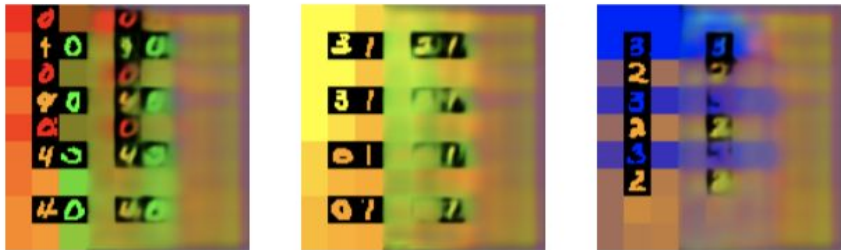

Original Image (Synthetic)

Original Image (Facades)

SGM (GLCIC, Synthetic)

SGM (GLCIC, Facades)

Baseline (GLCIC, Synthetic)

Baseline (GLCIC, Facades)

Future Work

- More expressive programs

- Better ways of incorporating program structure

- Domains beyond images