Ahsanullah University of Science & Technology

Department of Computer Science and Engineering

Thesis Defense

Title

Skeleton-based Jamdani Motif Generator using GAN

Thesis Supervised By

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JAMDANI MOTIF

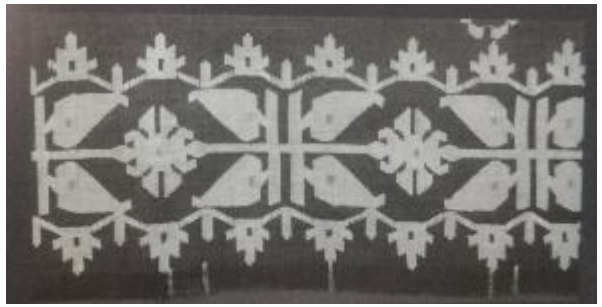
THE MASTERLY CRAFTMANSHIP

Jamdani, the only surviving cotton variant of **Dhakai Muslin,** declared as the **“Intangible Cultural Heritage of Humanity”** by **UNESCO** in 2013.

Jamdani Motifs are:

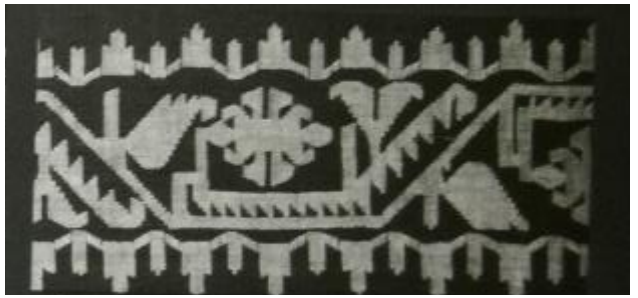
- Geometric exposition of flora & fauna of Bangladesh
- Not sketched on the fabric, but woven directly on the loom from the imagination stored in the minds of Artisans
- Formed by mathematical interlacing of wraps and weft

Naming The Motifs



Beelpata Paar

Beelpata Paar



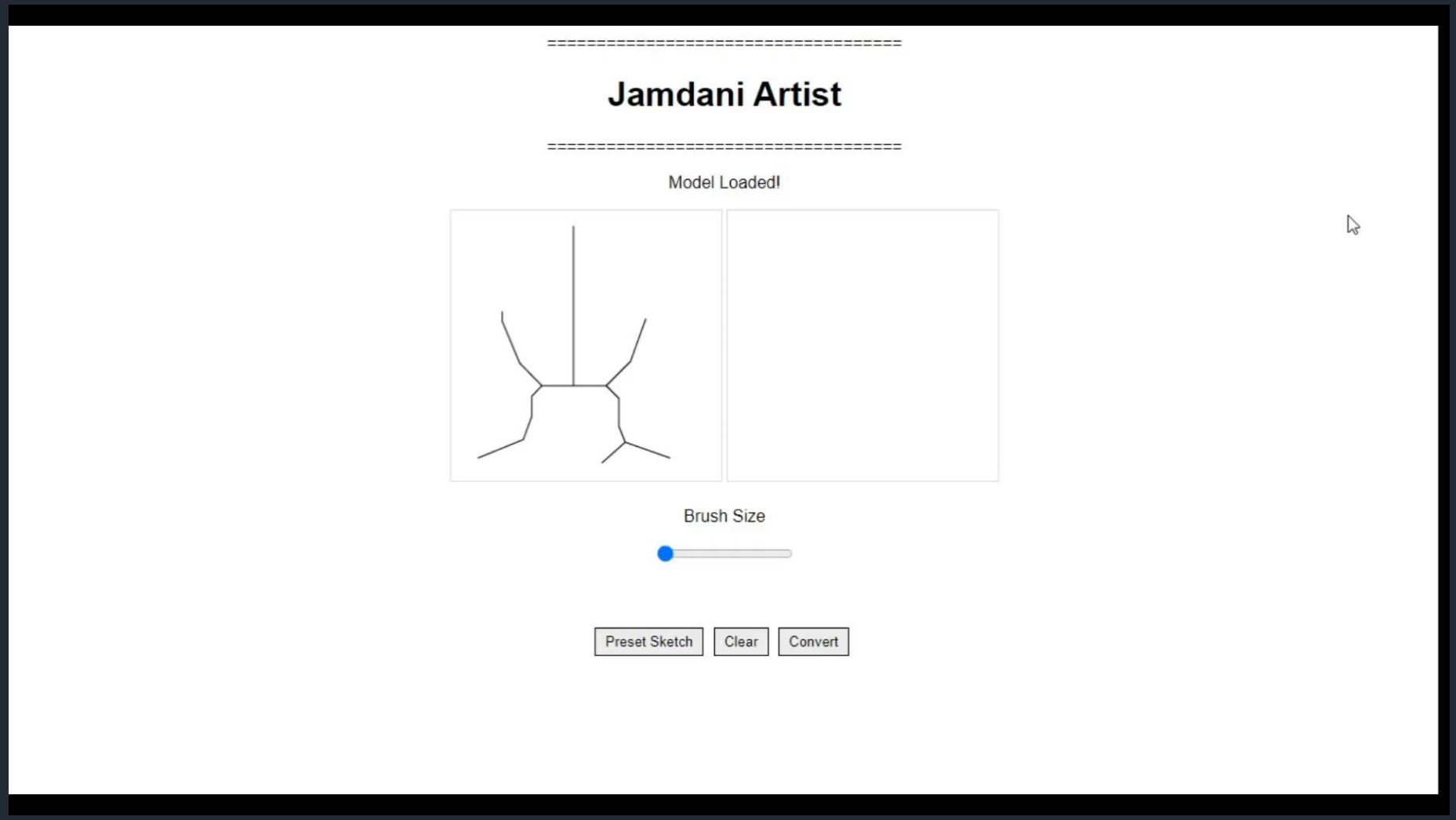
Beelpata Phool Paar

Indur Paar

Projapoti Phool

Source: Images collected from the book Traditional Jamdani Designs

Objective | Simulation of The Proposed System



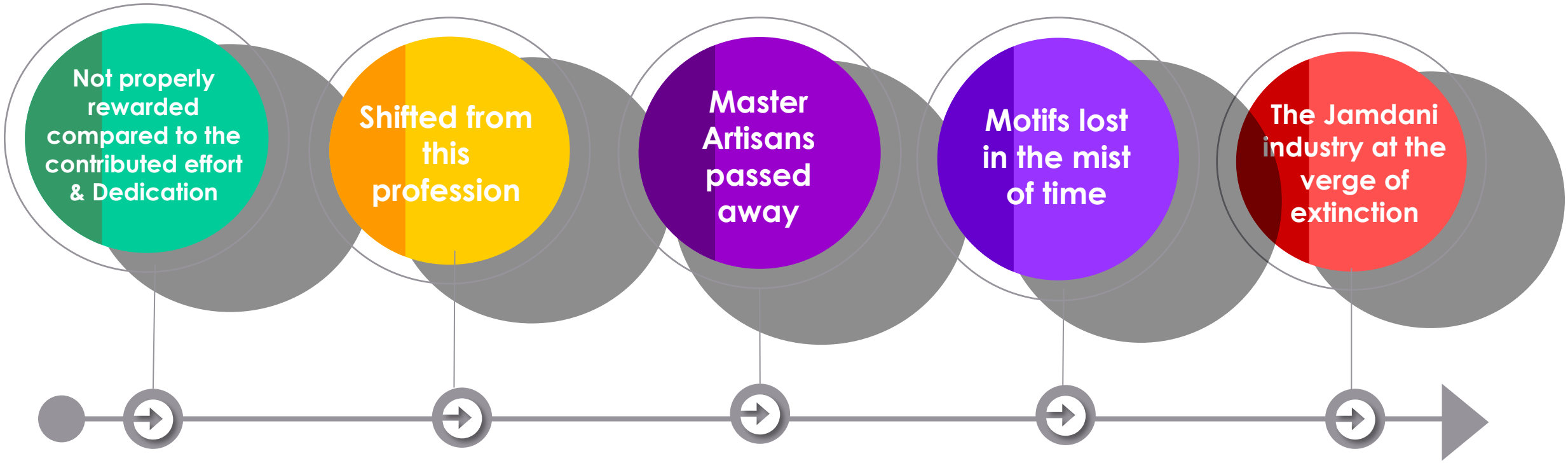
Motivation

- Why such a system is needed?
- How the system will help to improve current scenario?

The Butterfly Effect Through Ages

In the Past:

- Jamdani weaver played the role of both as an artisan and a weaver, designing from imagination while weaving on the loom.



Downbeat VS Upbeat

Current Scenario

- No Master Artisan alive now
- Weaver depend on catalogs for weaving motifs on the loom
- Earns **BDT 12** per hr.
- Works up to **14 hrs.** each day

Proposed Solution

Resuscitating the industry through a dedicated tool for Jamdani Motif generation can:

- Bridge the gap between weavers & Designers
- Preserve the surviving motifs
- An international exposure for this industry

Downbeat VS Upbeat

Current Scenario

Motifs are:

- No longer confined to textiles
- Being used nationally and internationally
- Are made into jewelry, home decor, curtains, utensils, etc.
- Created not by Jamdani weavers but by Artists, fashion designers, entrepreneurs, and craft enthusiasts

Proposed Solution

- An intelligent artist
- Make designing easier for enthusiast
- New source of inspiration for artists
- Keep the visual and artistic appeal of the produced motifs intact

Data Collection

- Building own dataset
- Ensure Data Authenticity

Two authentic sources:

- The Book: Traditional Jamdani Designs
- Direct Observation (A day tour in Jamdani Polli)

Jamdani Festival 2019

06 September - 12 October 2019

Bengal Shilpalay, Dhaka

- Introduction to the history & heritage of Jamdani
- Observation of motifs from different eras
- Dialogue with artists, designers and weavers
- Collected the the book titles “Traditional Jamdani Designs” an archive of authentic Jamdani motifs, which is one of our sources of data collection

The Exhibition

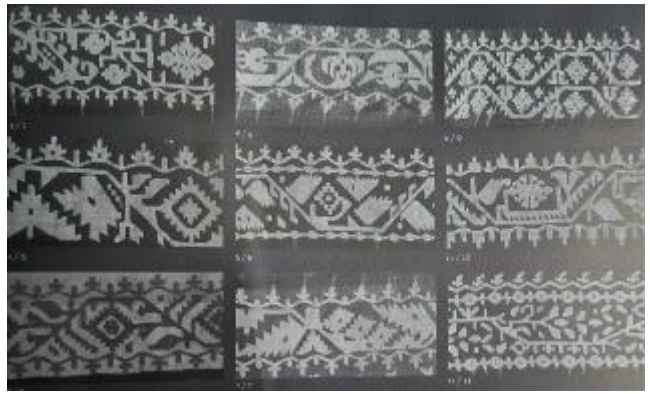
Our Team

Source: Images taken at Bengal Shilpalay at the Jamdani Festival 2019

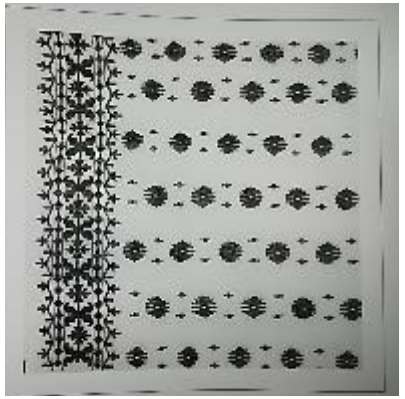
Sample Data Collected From The Archive

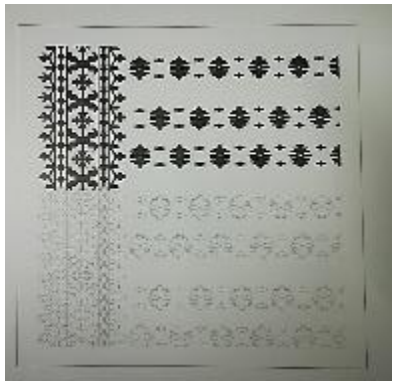
The Book: Traditional Jandani Design

Old Jamdani Motifs
Probably from 19th century



Contemporary Jamdani Motifs





Woven Design & Line Drawing Sample Pair

Source: Images taken from the book Traditional Jamdani Designs

A Day at Jamdani Polli

Tarabo, Shonargaon

Location: Shahina Jamdani Weaving Factory
Photo: Hand looms used for weaving Jamdani Saree

OUR ACTIVITIES

- Witnessed the entire Jamdani weaving process
- Interviewed the weavers
- **Data set collection**

The Process of Weaving & Data Collection

Preparing a Yarn

Weavers on the loom

Data Collection directly from the loom

Our Team

Location: Shahina Jamdani Weaving Factory

Samples of Data From Direct Observation

A saree with modern Jamdani design getting weaved on the loom

A Saree with traditional Jamdani motifs

Panjabi with Jamdani Motifs

Source: Photos of the motifs taken at Shahina Jamdani Weaving Factory

Background Study

❑ StyleGAN

- A Style-Based Generator Architecture for Generative Adversarial Networks
- Automatically learned, unsupervised separation of high-level attributes and it enables intuitive, scale-specific control of the synthesis

❑ CycleGAN

- Cross-domain transfer GANs will be likely the first batch of commercial applications. These GANs transform images from one domain (say real scenery) to another domain

❑ PixelDTGAN

Figure 2: From left to right: bicubic interpolation, deep residual network optimized for MSE, deep residual generative adversarial network optimized for a loss more sensitive to human perception, original HR image. Corresponding PSNR and SSIM are shown in brackets. [4× upscaling]

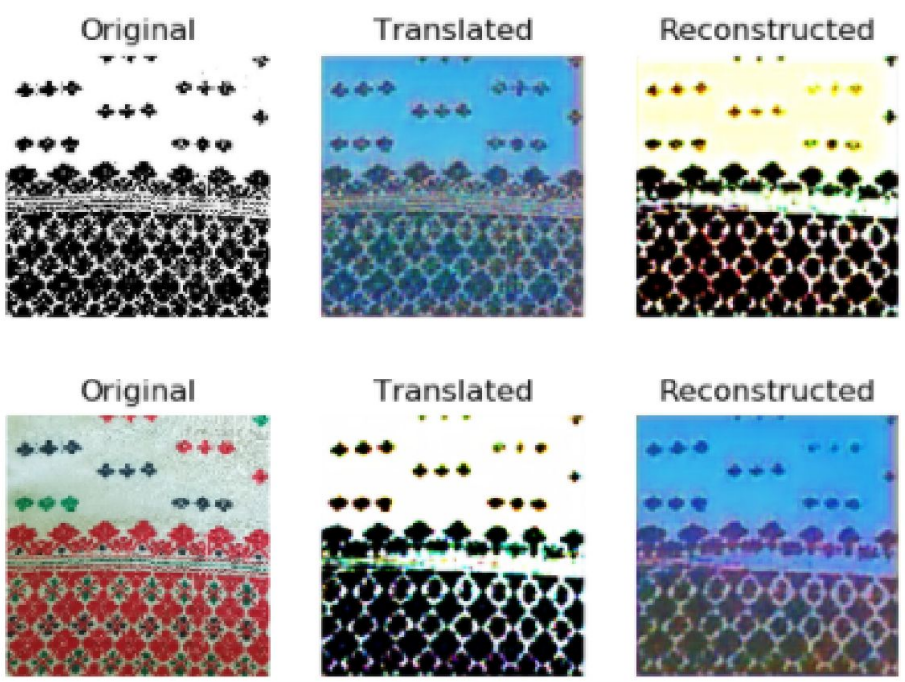
❑ ESRGAN

❑ LUCSS

❑ GauGAN

Hand-loom Design Generation

Using Deep Neural Networks



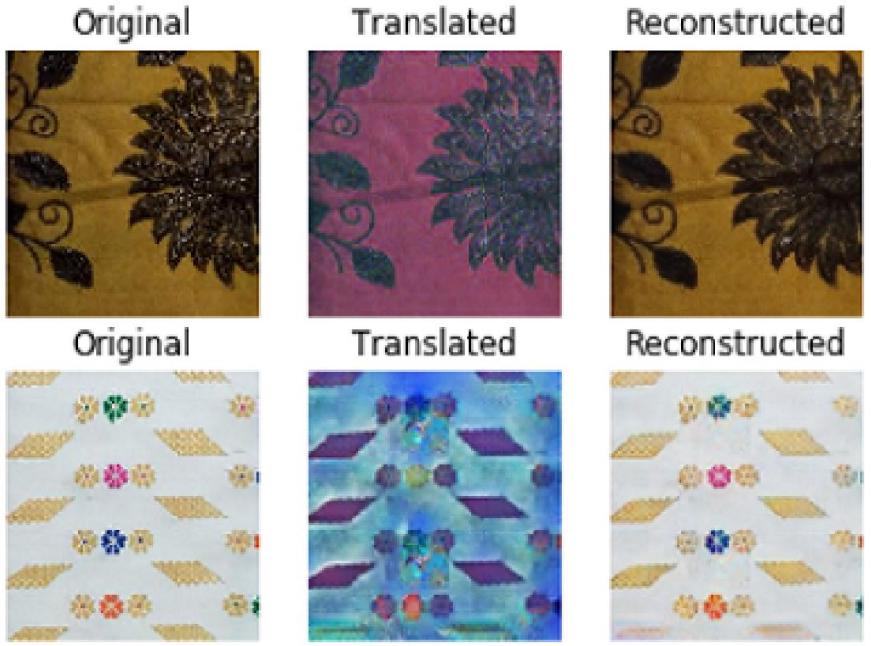


Fig: Handloom using CycleGAN (left) and DiscoGAN (right) version of their own dataset. In each group from left to right, the original saree image, translated image and the reconstructed image are shown respectively

Hand-loom Design Generation

Using Deep Neural Networks

Similarities

- Applied image-to-image translation techniques
- Developed an application while creating a unique dataset of Normal sarees and Handloom sarees

Dissimilarities

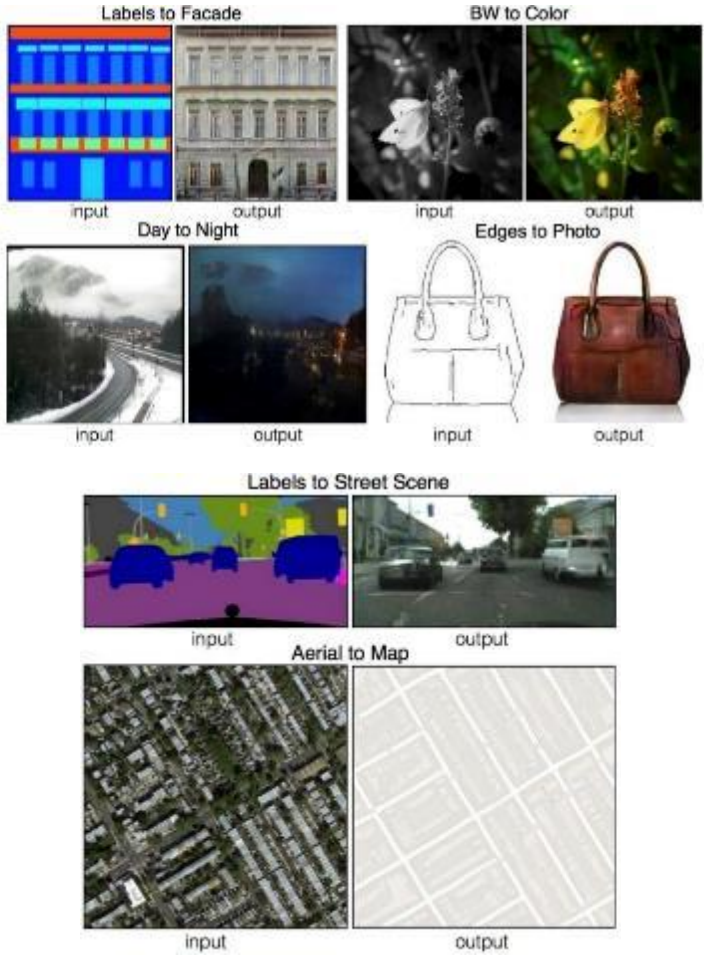
- The domain: Ours Jamdani; Theirs general handloom
- Focus: create the basic motif from a stroke whereas the referenced authors attempted creating a whole design.

Deep Dive Into Pix2Pix GAN

(Image-to-Image Translation with Conditional Adversarial Networks by Phillip Isola and others)

- Generic
- Does not require to define any relationship between the two types of images
- Makes no assumptions about the relationship
- Learns the objective during training, by comparing the defined inputs and outputs during training and inferring the objective

So we opted to go for a Pix2Pix inspired model!

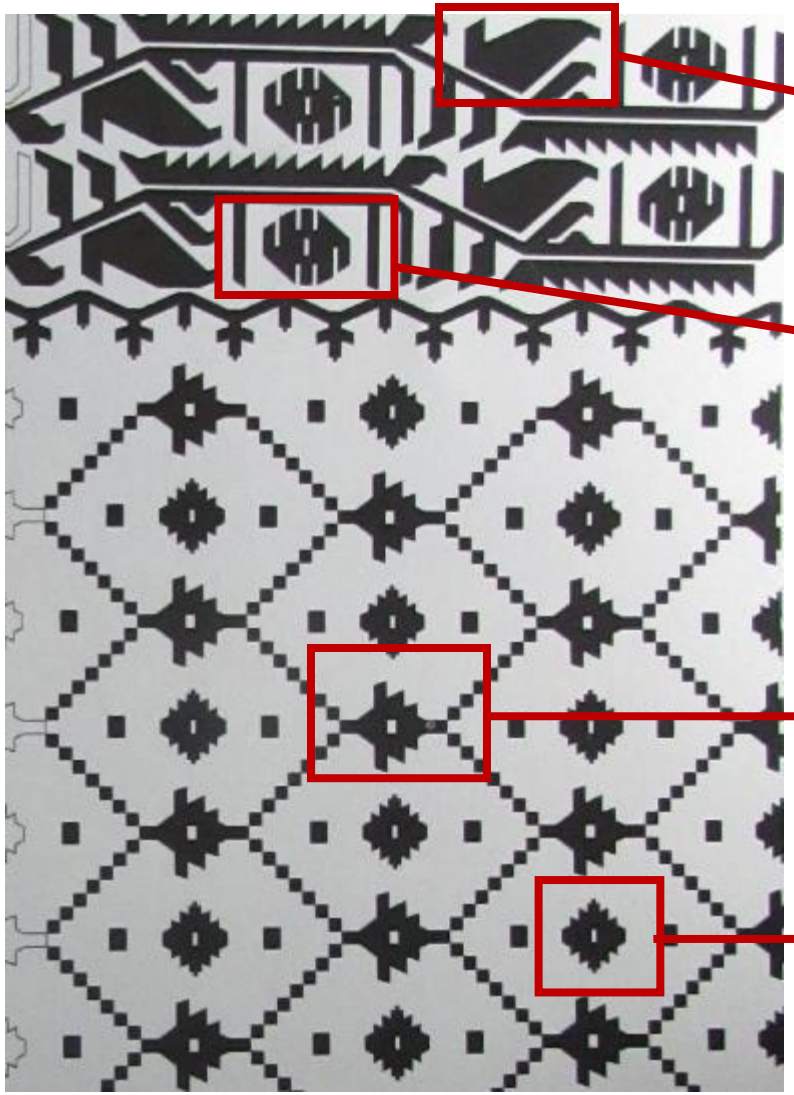


Building The Dataset: ***Jamdani Noksha***

Only available dataset of Jamdani motifs in digital format for computer vision research

Motif Extraction

Source: Image taken from the book Traditional Jamdani Designs



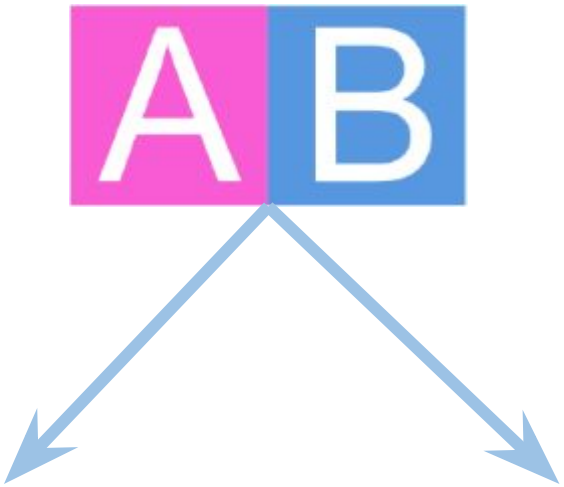
Jamdani Boarder Design

Extracted Motifs

Pix2Pix Data Format

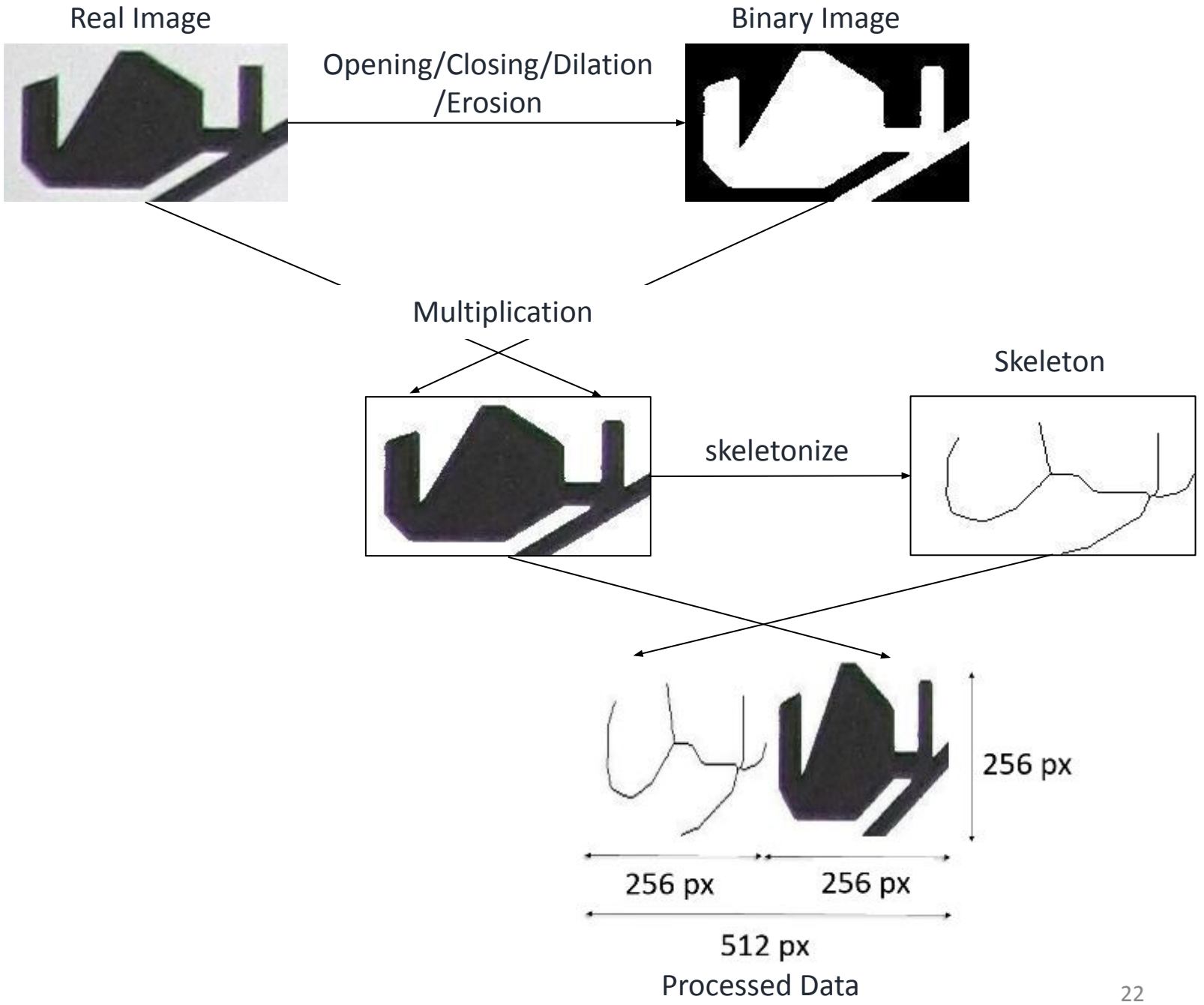
This type of data consists of input and desired output side by side :

(Boundary to Handbags type)



(Boundary to Shoes type)

Steps of Data Pre-processing



Reduced Branch Version

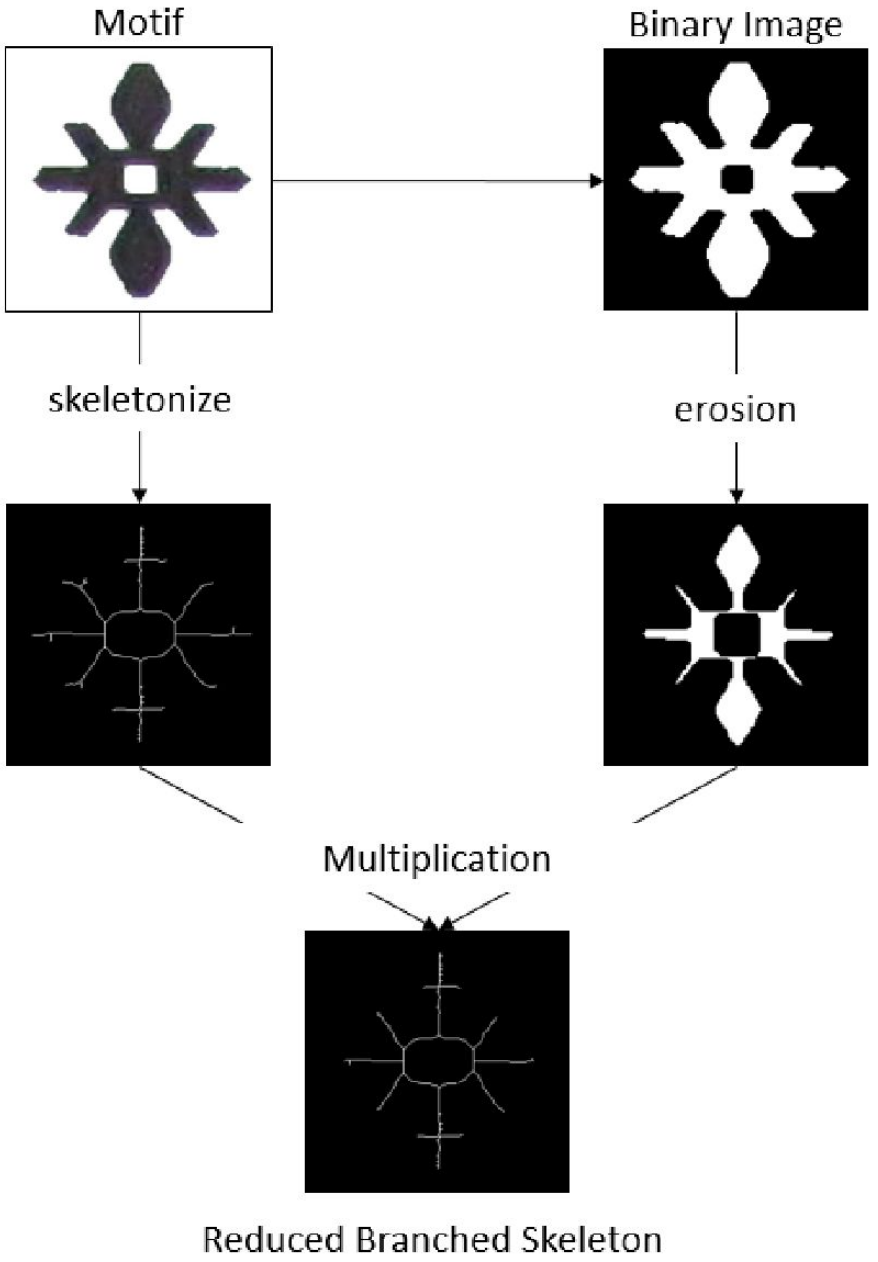


*Fig: Flow of processing data for **Reduced Branch Version***

Sketch Version

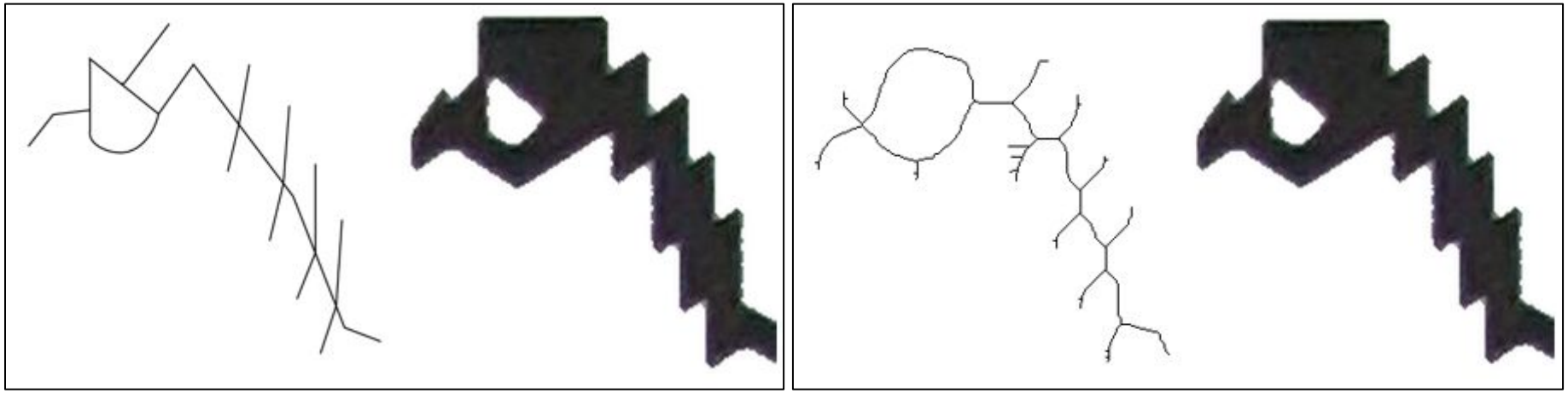


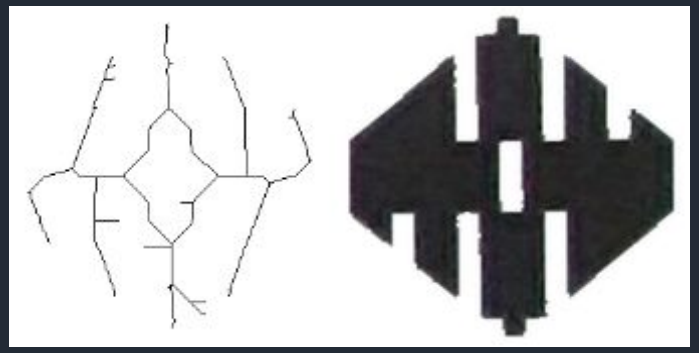
Fig: A visual comparison between sketch (left) and skeleton (right) version.

Different Versions of Dataset

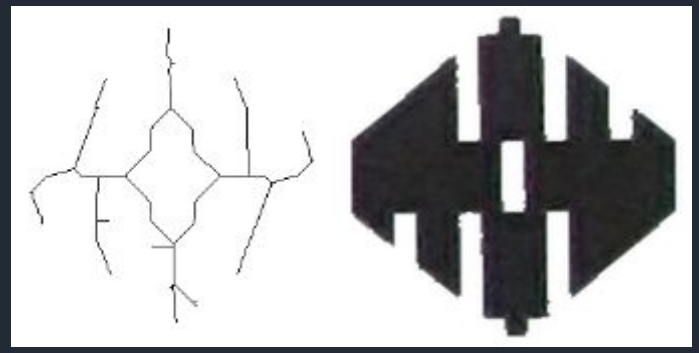
Five versions of the dataset ***Jamdani Noksha***—Skeleton, Reduced Branch, Sketch, Boundary, and Enhanced Resolution.

SL No	Version of Dataset	Size
1	Enhanced Resolution	1983
2	Reduced Branch	913
3	Sketch	910
4	Skeleton	7932
5	Boundary	1116

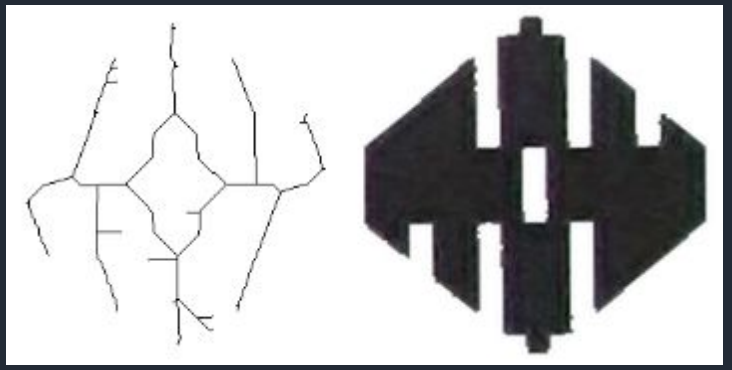
Samples of different variance of Dataset



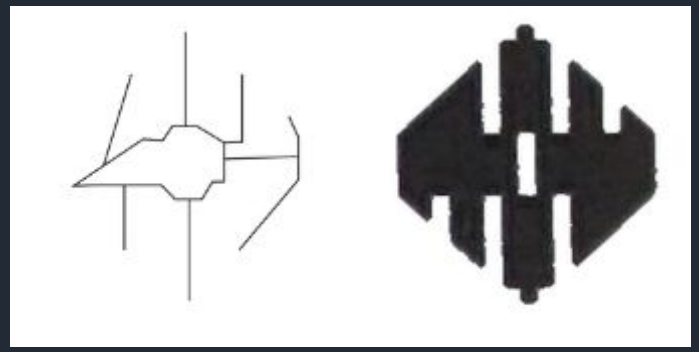
Skeleton



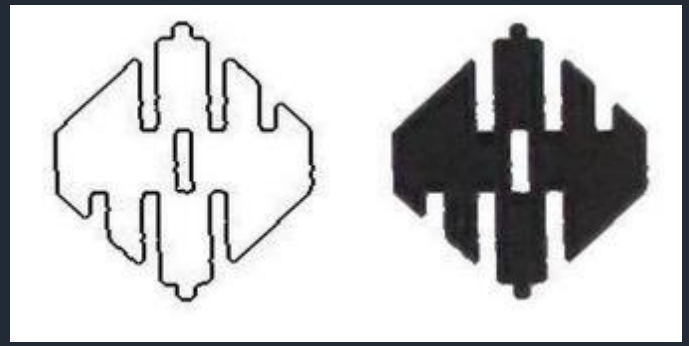
Reduced Branch



Enhanced Resolution



Sketch



Boundary

Methodology

The objective of a conditional GAN can be expressed as,

$$\mathcal{L}_{cGAN}(G,D) = \mathbb{E}_{x,y}[\log D(x,y)] + \mathbb{E}_{x,z}[\log(1 - D(x,G(x,z))]$$

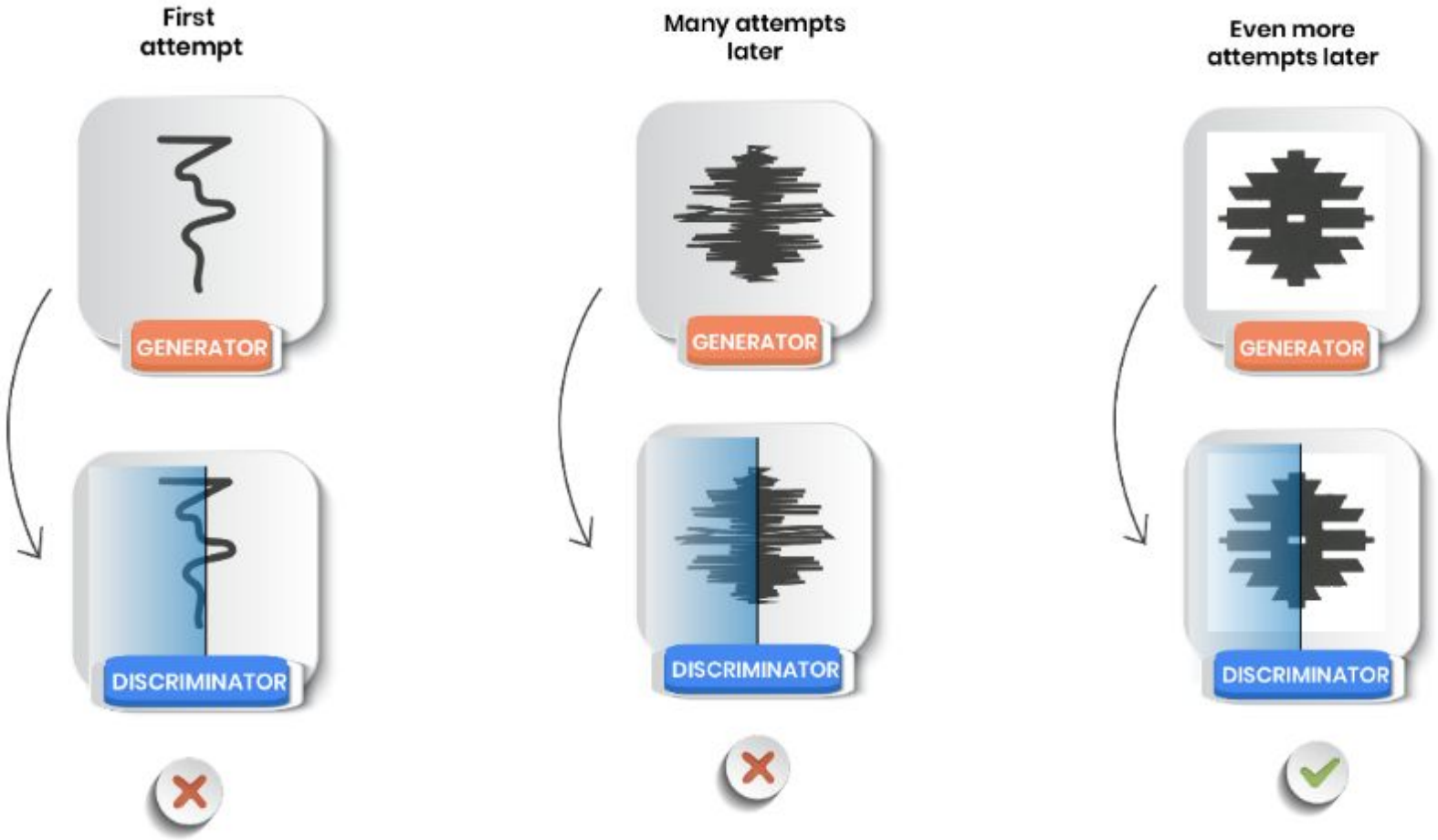
where G tries to minimize this objective against an adversarial D that tries to maximize it. The generator is tasked to not only fool the discriminator but also to be near the ground truth output in an L2 sense. We also explore this option, using L1 distance rather than L2 as L1 encourages less blurring,

$$\mathcal{L}_{L1}(G) = \mathbb{E}_{x,y,z}\left[\|y - G(x,z)\|_1\right]$$

Our final objective is,

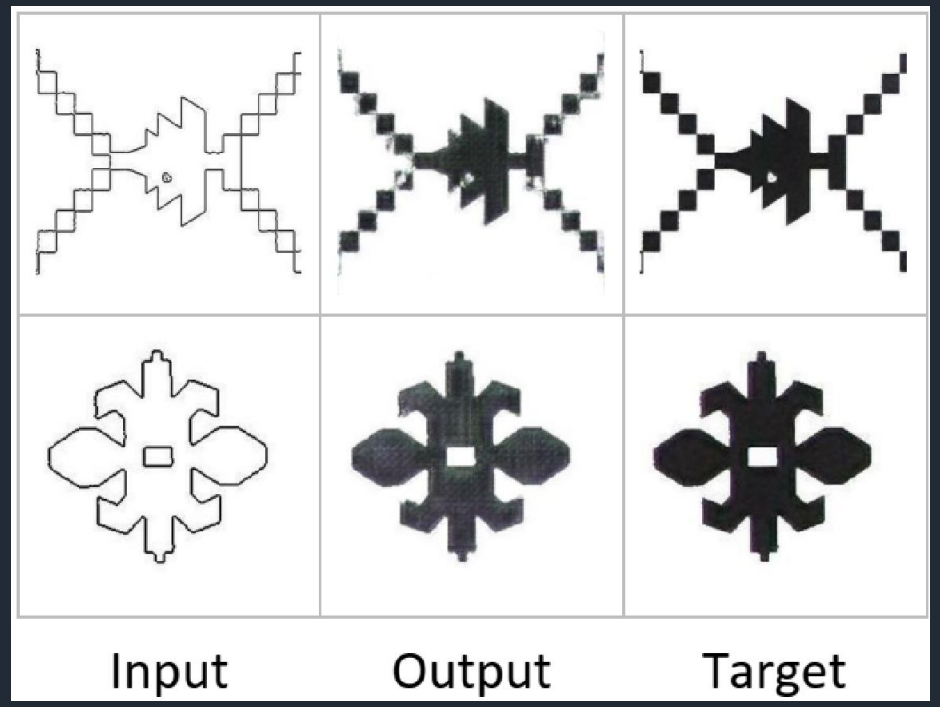
$$G^* = \arg\min_G \max_D \mathcal{L}_{cGAN}(G,D) + \lambda \mathcal{L}_{L_1}(G)$$

HOW DOES GAN WORKS?



Experiment & Result Analysis

Boundary Version



Sample output (middle column of each group) for model trained on Jamdani Noksha's Boundary, compared to ground truth (right column). Left column shows input strokes from user.

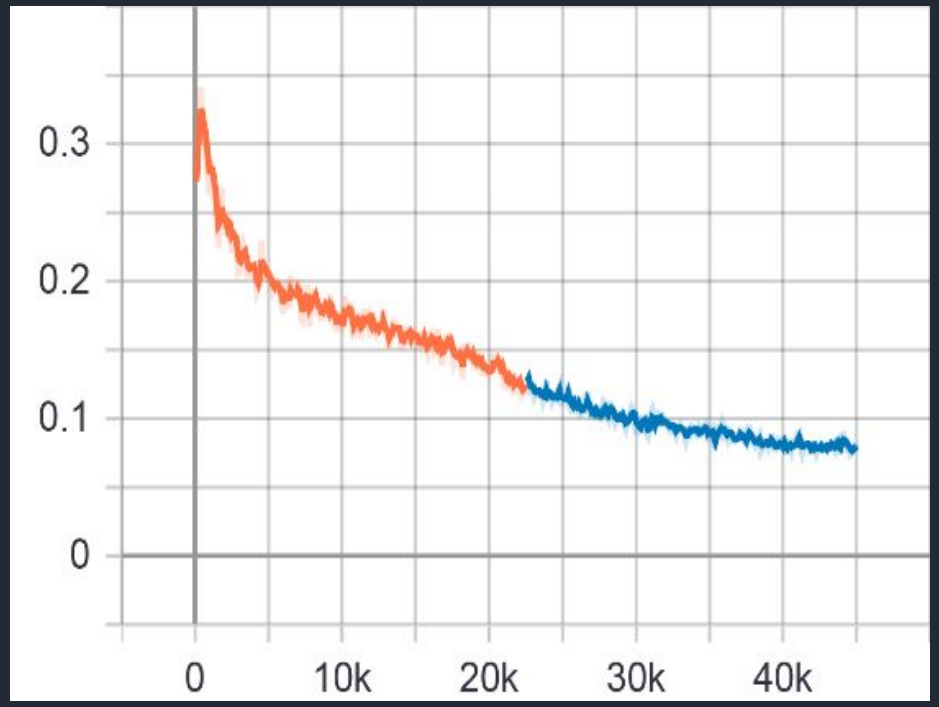
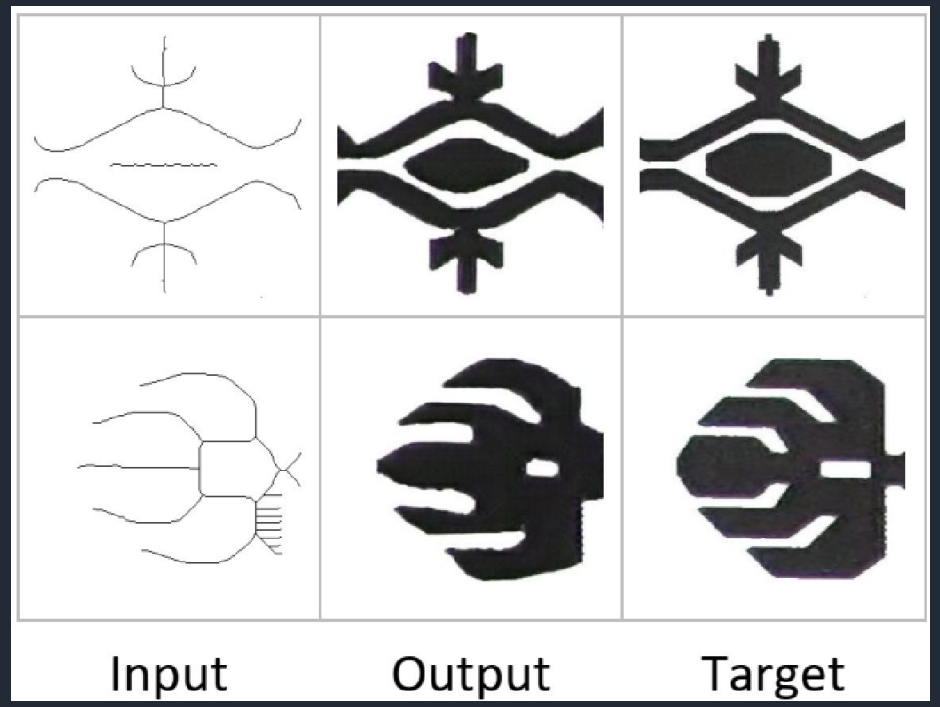


Fig: Loss graph for training on Boundary version

L1 indicates absolute pixel to pixel translation. As the number of iteration increases the L1 tends to get lower, i.e.: generator become more competent in producing images that matches the real image distribution.

Enhanced Resolution Version



Sample output (middle column of each group) for model trained on Jamdani Noksha's Enhanced Resolution, compared to ground truth (right column). Left column shows input strokes from user.

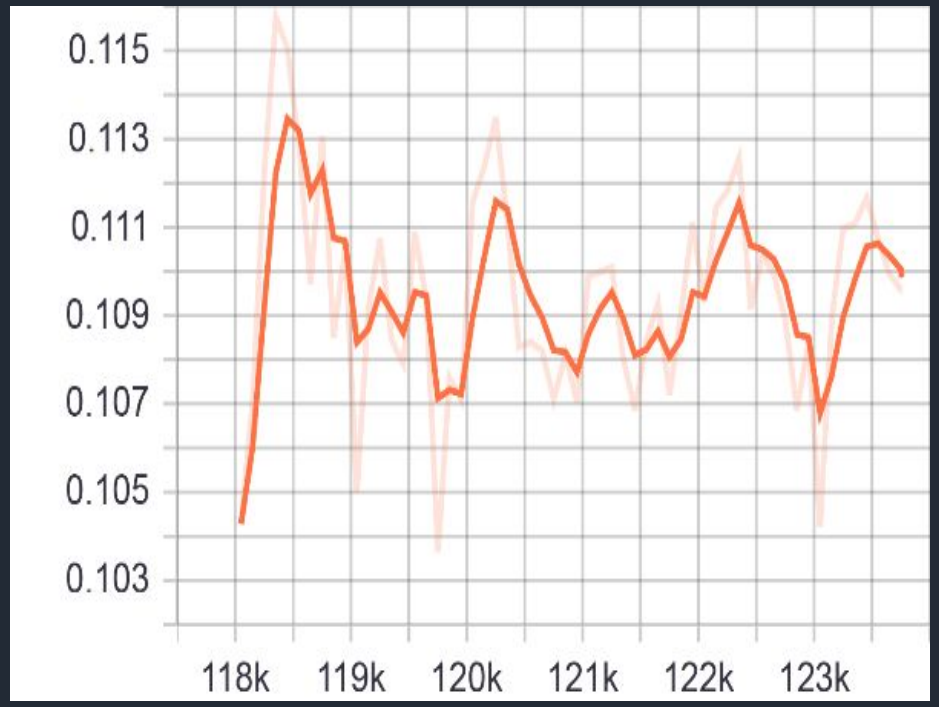
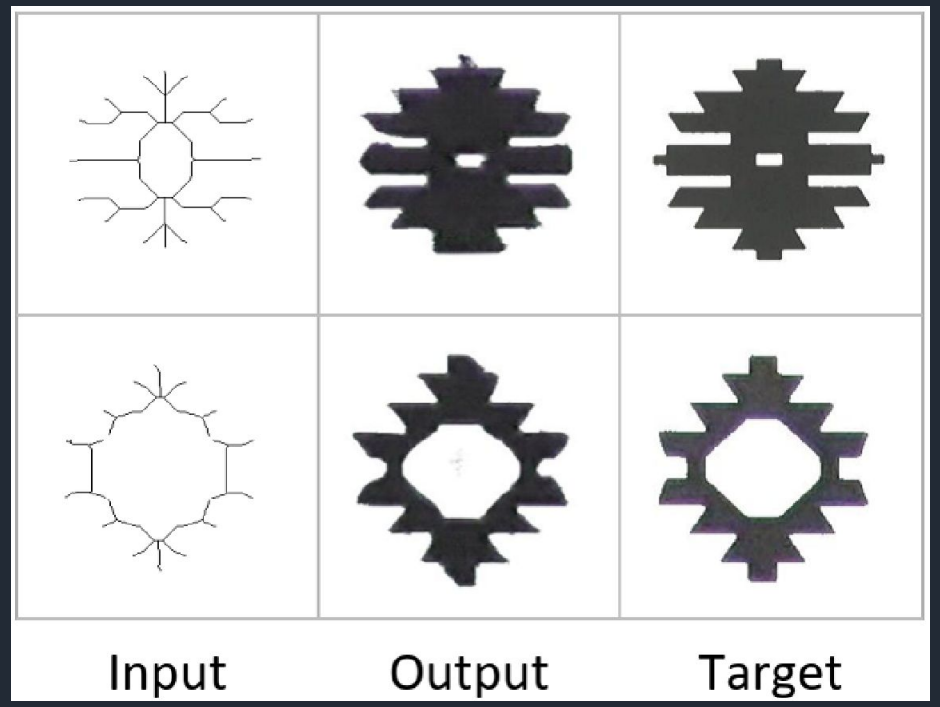


Fig: Loss graph for training on Enhanced Resolution version

L1 indicates absolute pixel to pixel translation. As the number of iteration increases the L1 tends to get lower, i.e.: generator become more competent in producing images that matches the real image distribution.

Reduced Branch Version



Sample output (middle column of each group) for model trained on Jamdani Noksha's, (Reduced Branch compared to ground truth (right column). Left column shows input strokes from user.

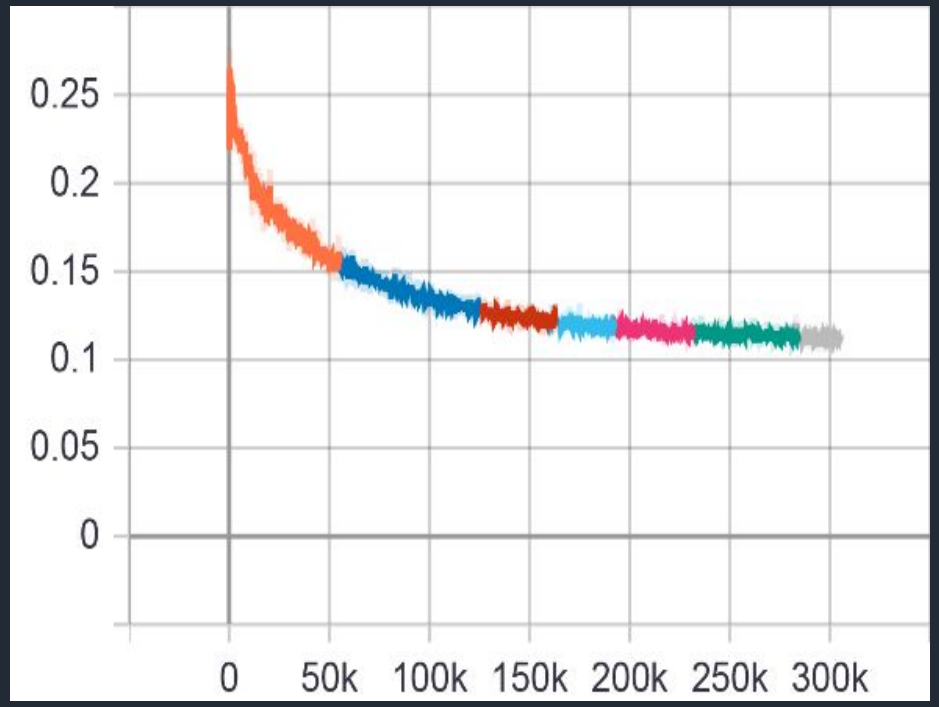
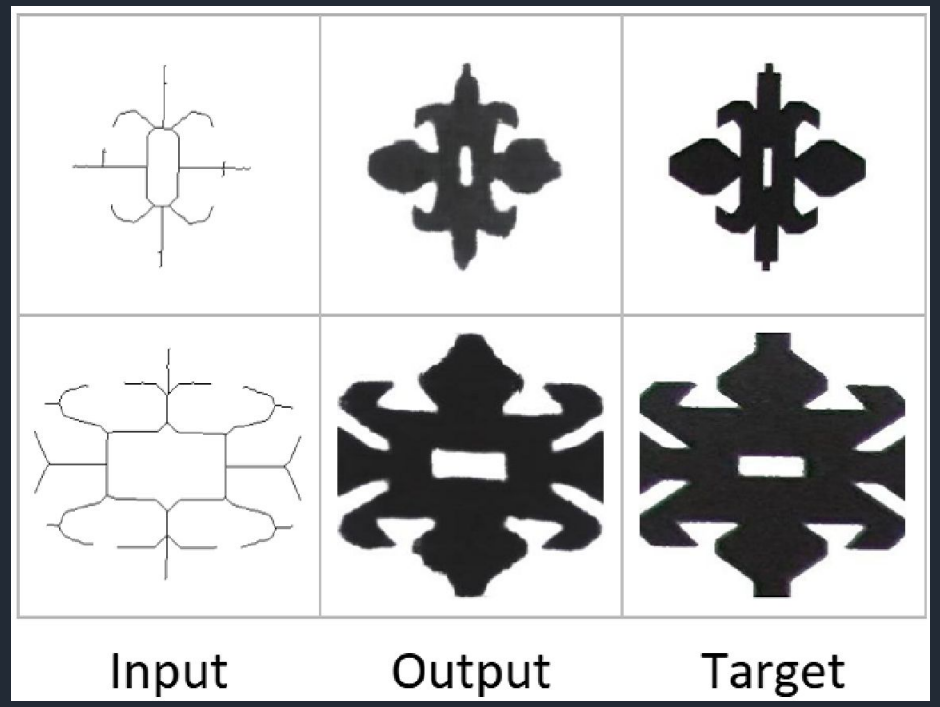


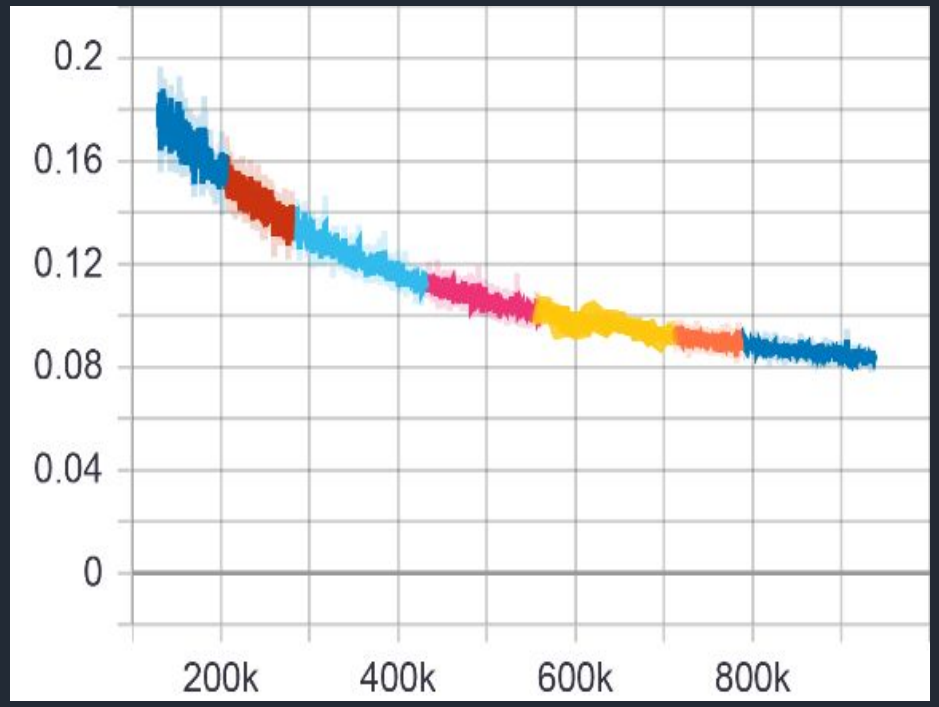
Fig: Loss graph for training on Reduced Branch version

L1 indicates absolute pixel to pixel translation. As the number of iteration increases the L1 tends to get lower, i.e.: generator become more competent in producing images that matches the real image distribution.

Skeleton Version



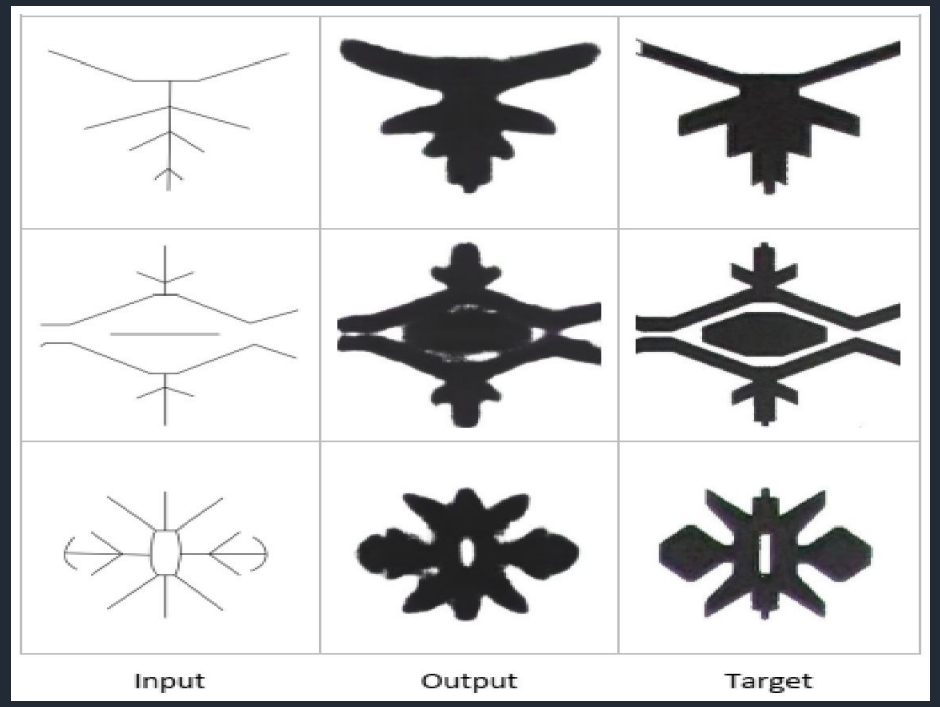
Sample output (middle column of each group) for model trained on Jamdani Skeleton, compared to ground truth (right column). Left column shows input strokes from user.



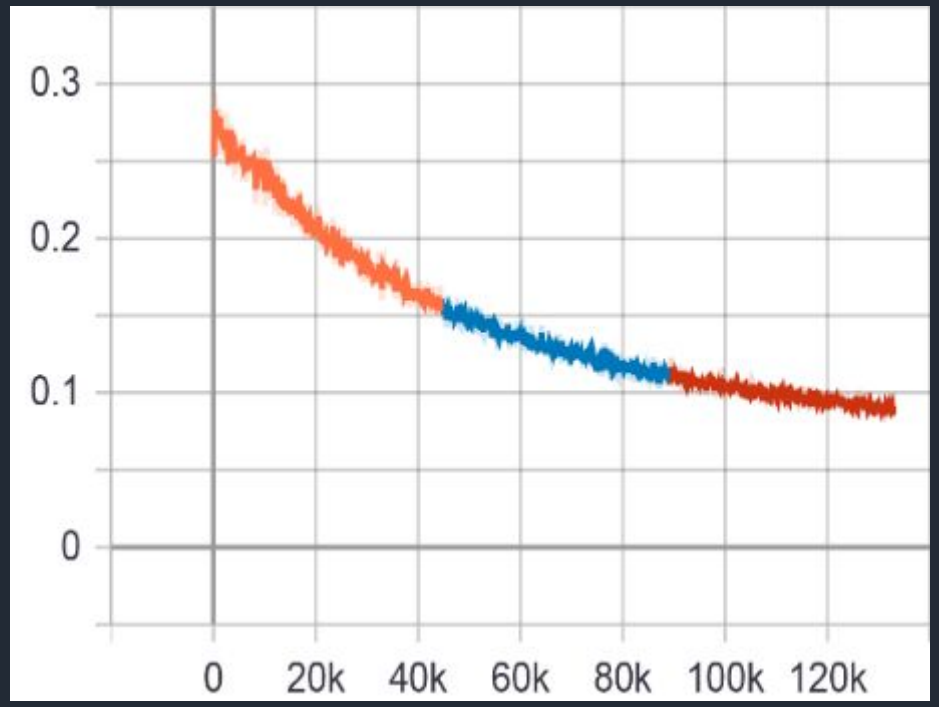
Loss graph for training on Skeleton version

L1 indicates absolute pixel to pixel translation. As the number of iteration increases the L1 tends to get lower, i.e.: generator become more competent in producing images that matches the real image distribution.

Sketch Version



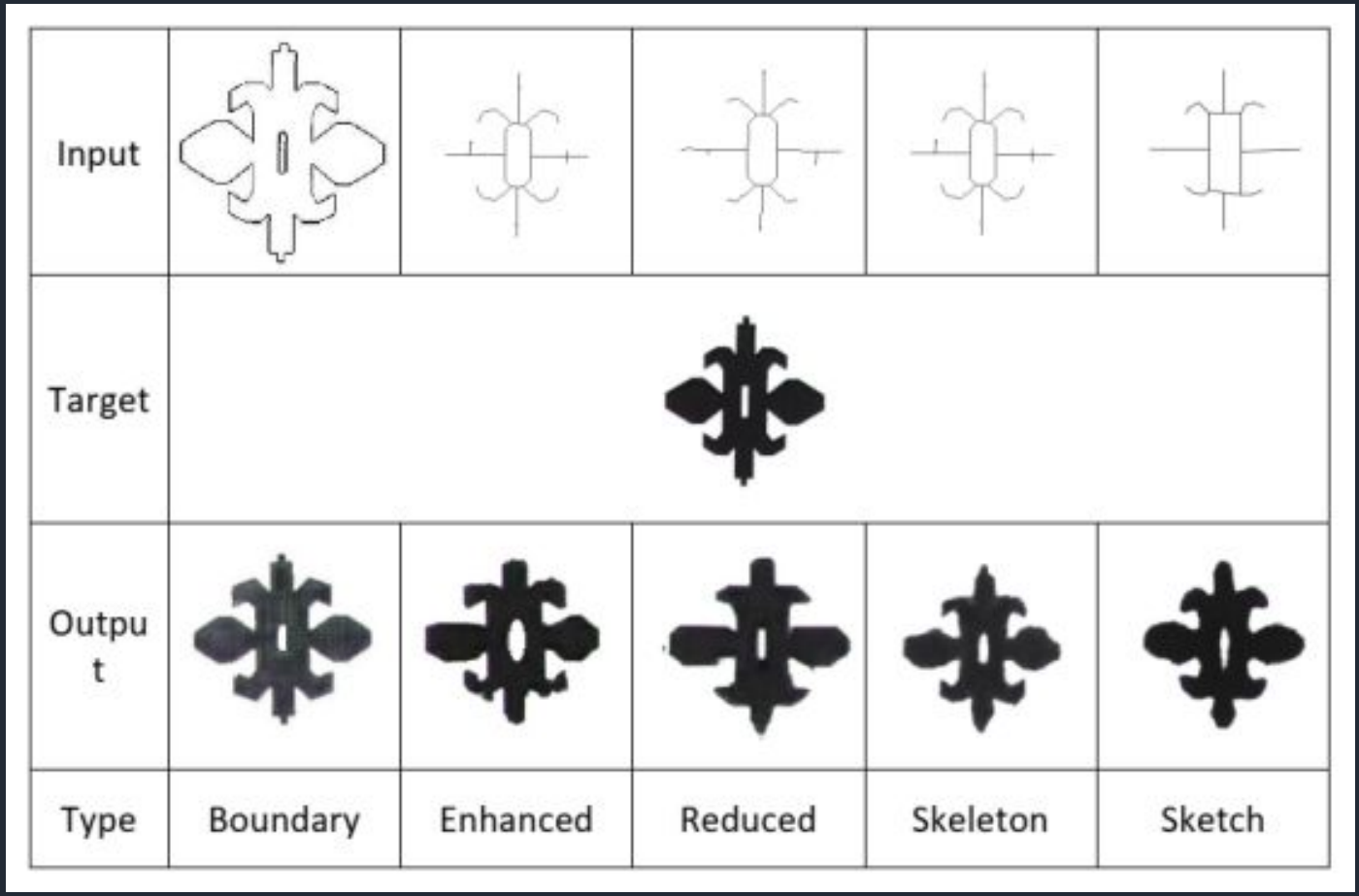
Sample output (middle column) for model trained on Jamdani Noksha's hand-drawn sketch version, compared to ground truth (right column). Left column shows input strokes from user.



Loss graph for training on Sketch version

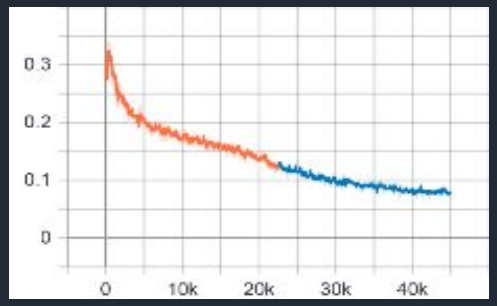
L1 indicates absolute pixel to pixel translation. As the number of iteration increases the L1 tends to get lower, i.e.: generator become more competent in producing images that matches the real image distribution.

Output Analysis

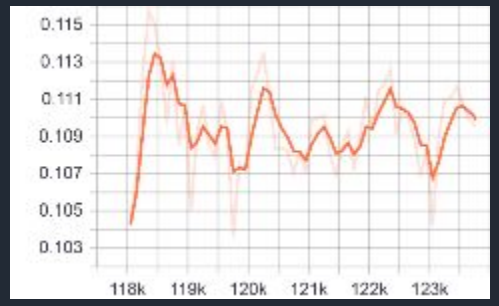


Outputs of 5 different versions of dataset

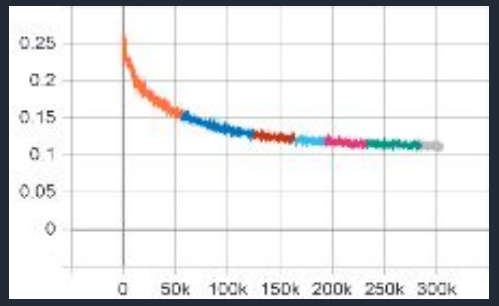
Loss Graph Analysis



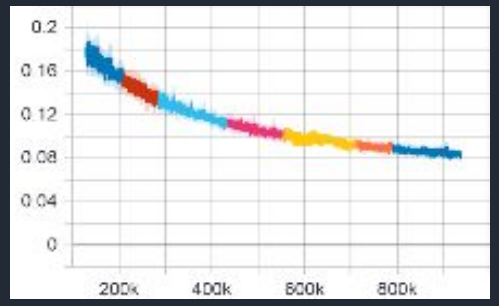
(a)



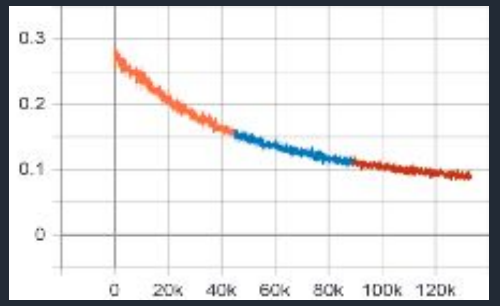
(b)



(c)



(d)



(e)

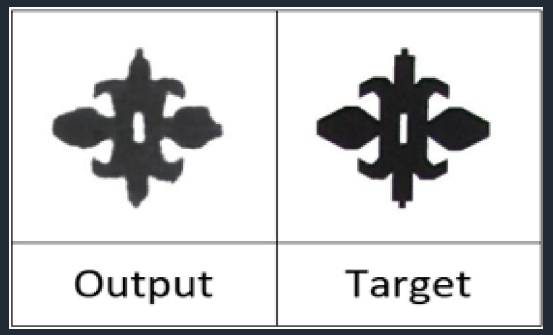
Loss graph for training on (a) Boundary, (b) Enhanced Resolution, (c) Reduced Branch, (d) Skeleton, and (e) Sketch version

Human Evaluation

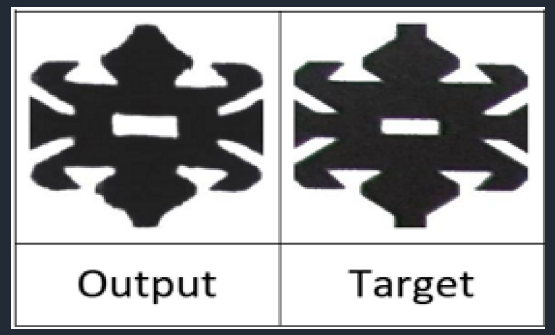
Survey on the accuracy

- Sample Size: 88
- Female participant 55.7% & Male participant 44.3%
- Dataset: ***Skeleton Version*** & ***Sketch Version***
- Total number of random samples provided for evolution: 10 (5 Samples of ***Skeleton*** & 5 Samples of ***Sketch*** Dataset)

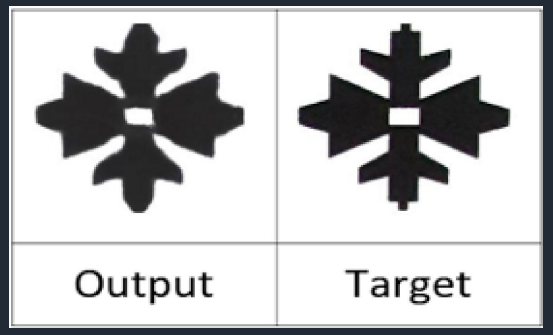
Samples from *Skeleton Version*



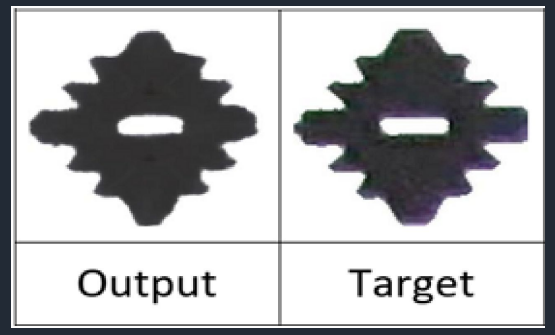
69.2%



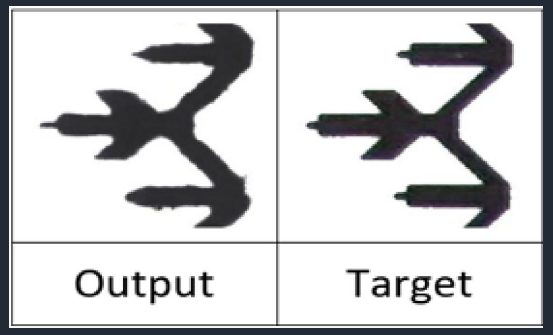
80.7%



71.7%



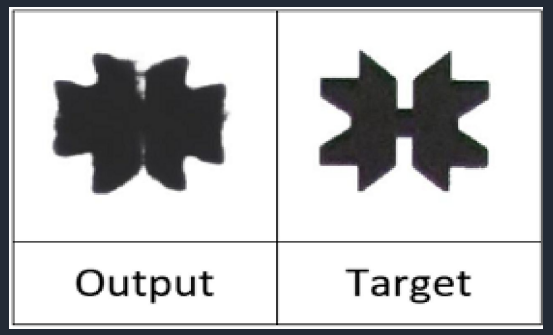
78.3%



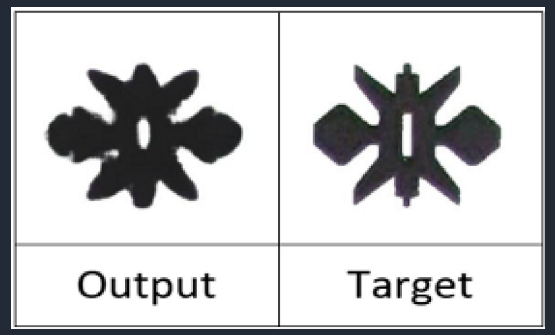
72.5%

Average score 7.45 out of 10.
Accuracy 74.5%.

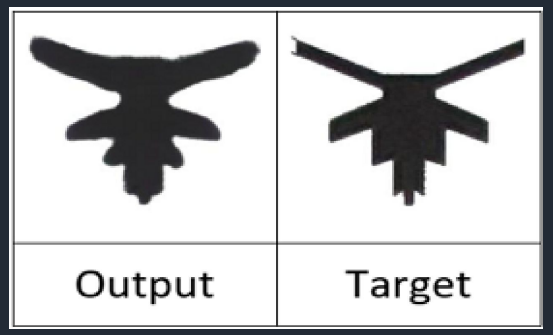
Samples from *Sketch Version*



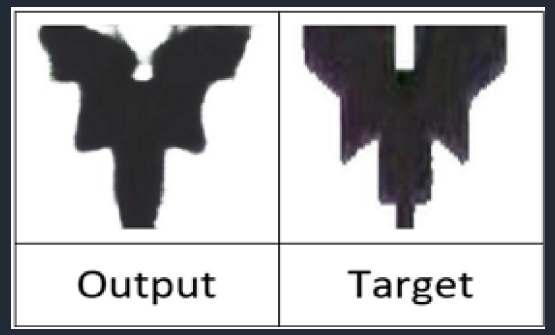
50.1%



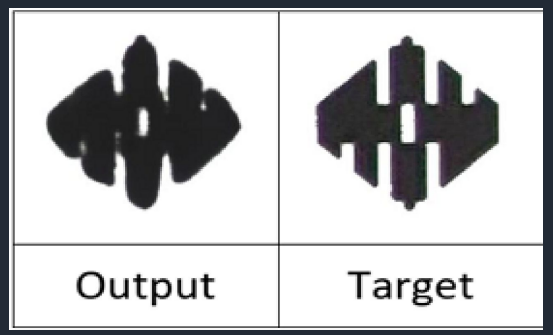
58.9%



64.4%



59.7%



55.6 %

Average score 5.77 out of 10.
Accuracy 57.7%.

Findings From The Survey

For ***Skeleton Version*** of Dataset:

- The largest version of dataset → Better output
- Projected accuracy of human evaluation → 74.5%

For ***Sketch Version*** of Dataset:

- The smallest version of dataset → Less edgy output
- Projected accuracy of human evaluation → 57.7%

For a data hungry architecture like GAN, more data means more visual aesthetics!

Limitation & Future Work

Constraints:

- Insufficiency of data
- The Sketch Version of ***Jamdani Noksha*** Dataset has only 250 data. As the sketches are drawn by hand which is a time consuming process large number of data couldn't be produced.

Future Work:

- More realistic and flawless OUTPUT
- Classify original Jamdani from fake ones
- Generate larger designs
- Convert different objects into a geometric pattern that resembles the hand-loomed Jamdani designs.

Sneak Peak Of The Future Scope

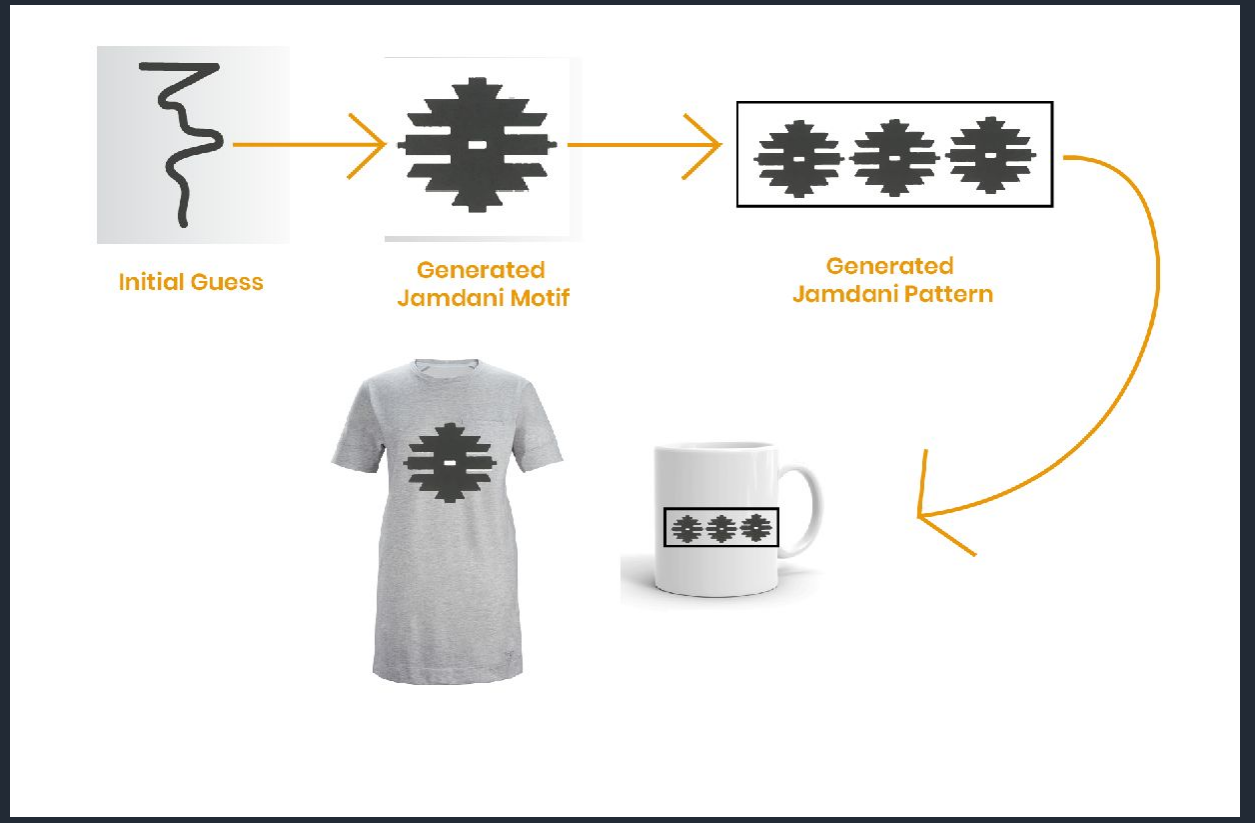


Fig: An anticipated system showing complicated design creation from a single motif and transferring design on different domain

ANY QUESTIONS?

THANK YOU!