# Supplemental Material: JointFontGAN: Joint Geometry-Content GAN for Font Generation via Few-Shot Learning

## **1 EXAMPLES OF FONT DATASET**

Fig. 1 and Fig. 2 show some examples of Capitals64 and SandunLK64 font datasets used in this work.

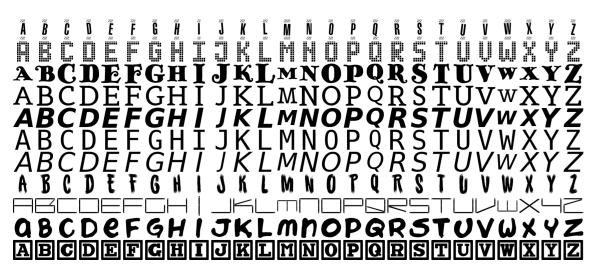


Figure 1: Examples of Capitals64 font dataset.

N a B b G c B d E e F	fagwhii	JKKLIMMM	n B u P p B q R r S s	. T t U u V v W w X x Y y Z z . , ; : ! ? ' "
AaBbCcDdEeF	fGgHhli	JjKkLlMmNr	n O o P p Q q R r S s	T
A a B b C c D d E e F	f G g H h l i	] j K k L i M m N n	n O o P p Q q K r S s	Ττ Ü σ V ν W ω X x Y y Z z . , ; : ! ? ' "
AaBbCcDdEeF	fGgHhli	liKkLlMmNn	nOoPpOgRrSs	T t U u V v W w X x Y y Z z . , ; : ! ? ' "
				TTUUVVUUXXYYZZ= , , : ! P ° ~
				T t U u V v W w X x Y y Z z . , ; : ! ? ' "
. <u></u>	F & € Н Н † +	++**t+M¤N»	N 8 8 9 9 8 8 9 9 8 8 3 5	- Ŧ Ŧ Ħ Ħ ₩ ₩ ₩ ₩ X X Y Y E E ; : 1 ? ' "
	P B B B B I I			T & # # V V W W # # # # # Z Z : : ! ? ' '
				TtUuVvWwXxYyZz.,;:!?'"
			п о о в р ц q к г ъ з	T T U U V V W W X X Y Y Z Z . , ; : ! ?
AaBbCcDdEeF	FGAHLLI			•
	juginiii	J j K k L I M m N r	n O o P p Q q R r S s	T t U u V v W w X x Y y Z z . , ; : ! ? ' "
A a B b C c D d E e F	, , ,	-		T t U u V v W w X x Y y Z z . , ; : ! ? ' " T t U u V v W w X x Y y Z z . , ; : ! ? ' "
	fGgHhli	JjKkLIMmNn	n O o P p Q q R r S s	TtUuVvWwXxYyZz.,;:!?'"
<b>A A B B C C D D E E F</b>	f G g H h I i F a a m m t t	J j K k L I M m N n J J K K L L M M N K	n O o P p Q q R r S s N <b>O O P P Q Q R R S S</b>	Т t U u V v W w X x Y y Z z . , ; : ! ? ' " : тта ш v v w w x x x x z z . , ; : ! ? - "
<b>A A B B C C D D E E F</b>	f G g H h I i F a a m m t t	J j K k L I M m N n J J K K L L M M N K	n O o P p Q q R r S s N <b>O O P P Q Q R R S S</b>	TtUuVvWwXxYyZz.,;:!?'"
<b>A A B B C C D D E E F</b> A a B b C c D d E e F	f G g H h I i <b>F G G H h I i</b> f G g H h I i	J j K k L I M m N n J <b>J K K L L M M K K</b> J j K k L I M m N r	n O o P p Q q R r S s N O O P P G G R R S S n O o P p Q q R r S s	T t U u V v W w X x Y y Z z . , ; : ! ? ' " <b>T T U U V v W w X x Y y Z z . , ; : ! ? ' "</b> T t U u V v W w X x Y y Z z . , ; : ! ? ' "
<b>A A B B C C D D E E F</b> A a B b C c D d E e F <b>A A B B C C D D E E F</b>	f G g H h I i F G G H H I I f G g H h I i F G G H H I I	J j K k L I M m N n J J K K L L M M K A J j K k L I M m N r J J K K L L M M N N	n 0 o P p 0 q R r S s N <b>0 0 P P 0 q R r S s</b> n 0 o P p Q q R r S s N <b>0 0 P P Q Q R R S S</b>	T t U u V v W w X x Y y Z z . , ; : ! ? ' " <b>T T U U V v W w X x Y y Z z . , ; : ! ? ' "</b> T t U u V v W w X x Y y Z z . , ; : ! ? ' " <b>T T U U V V W W X X Y Y Z Z . , ; : ! ? ' "</b>
A A B B C C D D E E F   A a B b C c D D E E F   A a B b C C D D E E F   A a B b C c D D E E F	f G g H h I i F G g H h I i	J j K k L I M m N m J J K K L L H H M N N J J K k L I M m N r J J K K L I M m N r J J K k L I M m N r	n 0 o P p 0 q R r S s N <b>G G P P G G R R S S</b> N 0 o P p Q q R r S s N 0 <b>0 P P Q Q R R S S</b> N 0 <b>0 P P Q Q R R S S</b>	T t U u V v W w X x Y y Z z . , ; : ! ? ' " <b>T T U U V v W w X x Y y Z z . , ; : ! ? ' "</b> T t U u V v W w X x Y y Z z . , ; : ! ? ' "

Figure 2: Examples of SandunLK64 font dataset.

### 2 ADDITIONAL RESULTS ON FONT GENERATION

Fig. 3 and Fig. 4 show some additional visualization comparison results of our JointFontGAN model, zi2zi [2], and Glyph Network in MC-GAN [1] on Capitals64 dataset.

### **3** ABLATION STUDY – TESTING L<sub>1</sub> ERRORS

Fig. 5 shows the  $L_1$  error curves (on testing) for ablation study on Capitals64 dataset during the training stage for different epochs, which can further explain the effects of the proposed main components.

Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	ABCDEFGHIJKLMNOPQRSTUVWXYZ ABCDEFGHIJKLMNOPQRSTUVWXYZ ABCDEFGHIJKLMNOPQRSTUVWXYZ ABCDEFGHIJKLMNOPQRSTUVWXYZ ABCDEFGHIJKLMNOPQRSTUVWXYZ ABCDEFGHIJKLMNOPQRSTUVWXYZ
Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	
Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	Image: Separation of the separation
Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	A B C D E F G H J B L M O P Q R S T U W X J Z   A B C D E F G H J K L M N O P Q R S T U W X J Z   A B C D E F G H J K L M N O P Q R S T U W X J Z   A B C D E G H J K L M O P Q R S T U U W X J Z   A B C D E G H J K L M M D D U U U U U U U

Figure 3: Additional visualization comparison for our JointFontGAN model on Capitals64 dataset. The ground truth glyphs and the few-shot reference sets (marked in red boxes) are shown in the 1st row. The 2nd row shows the results of zi2zi [2]. The 3rd row shows the results of Glyph Network in MC-GAN [1]. The 4th row shows the results of our model. The 5th row shows our skeleton results. The 6th row shows the ground truth skeletons and the few-shot reference sets (marked in red boxes).

## 4 QUALITATIVE ANALYSIS OF THE NUMBER OF OBSERVED LETTERS

Fig. 6 shows the qualitative performance of our method with three different few-shot observed letter settings (i.e., one, four, and eight random input samples) on Capitals64 dataset.

### 5 QUALITATIVE RESULTS ON COLORED / ORNAMENTED GLYPHS

In order to demonstrate the further capability of generating colored / ornamented glyphs, we apply a two-stage model followed by a (similar) Ornamentation Network in [1] with three RGB channels to our JointFontGAN. Some preliminary results are shown in Fig. 7 with visualization comparison results of our JointFontGAN + Ornamentation Network (without fine-tuning) and MC-GAN [1]. It is worth to mention that although the primary goal of our current work is to improve quality of generated (gray-scale) glyphs by adapting to the geometric variability and content scalability, our colored results are better than those of MC-GAN (e.g., more consistent font styles and font contents). We will explore some new methods to focus on the colored / ornamented glyph generation in the future.

Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	<b>HECDEFGHIJKLMNOPQRSTUVWXYZZ ABCDEFGHIJKLMNOPQRSTUVWXYZZ ABCDEFGHIJKLMNOPQRSTUVWXYZZ ABCDEFGHIJKLMNOPQRSTUVWXYZZ ABCDEFG HIJKLMNOPQRSTUVWXYZZ ABCDEF HIJKLMNOPQRSTUVWXYZZ ABCDE HIJKLMNOP HIJKLMNOP HIJKLMNOP HIJKLMNOP HIJKLMNOP HIJKL HIJKL HIJK HIKK HIJK</b>
Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	ABCDEFGHIJKLMNOPORSTUVWXYZ   ABCDEFSHIJKLMNOPORSTUVWXYZ   ABCDEFSHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ   ABCDEFCHIJKLMNOPORSTUVWXYZ
Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	A B C D E F G H I J K L M N D P O R S T U V W X Y Z A B C D E F G H I J K L M N D P O R S T U V W X Y Z A B C D E F G H I J K L M N D P O R S T U V W X Y Z A B C D E F G H I J K L M N D P O R S T U V W X Y Z A B C D E F G H I J K L M N D P O R S T U V W X Y Z A B C D E F G H I J K L M N D P O R S T U V W X Y Z
Ground truth zi2zi Glyph Network Ours Our skeletons GT skeletons	A B C D E F G H I J K L M O P O R S T U U W Y Z   A B C D E F G H I J K L M N O P O R S T U V W Y Z Z A B C D E F G H I J K L M N O P O R S T U V W Y Z Z A B C D E G H I J K L M N D P O R S T U U W W Z Z A B C D E G H L H U U U U U U U U

Figure 4: Additional visualization comparison for our JointFontGAN model on Capitals64 dataset (continue). The ground truth glyphs and the few-shot reference sets (marked in red boxes) are shown in the 1st row. The 2nd row shows the results of zi2zi [2]. The 3rd row shows the results of Glyph Network in MC-GAN [1]. The 4th row shows the results of our model. The 5th row shows our skeleton results. The 6th row shows the ground truth skeletons and the few-shot reference sets (marked in red boxes).

#### **REFERENCES**

- Samaneh Azadi, Matthew Fisher, Vladimir Kim, Zhaowen Wang, Eli Shechtman, and Trevor Darrell. 2018. Multi-content GAN for few-shot font style transfer. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 7564–7573.
- [2] Yuchen Tian. 2017. zi2zi: Master Chinese calligraphy with conditional adversarial networks. https://kaonashi-tyc.github.io/2017/04/06/zi2zi.html.

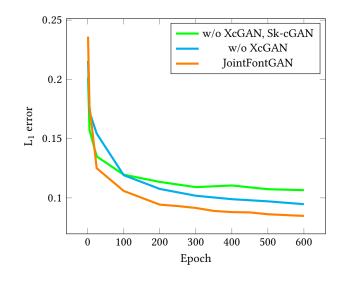


Figure 5: Testing L<sub>1</sub> errors for ablation study on Capitals64 dataset for different training epochs.

Ground truth	R B C D E F G H I J K L M H O P O R S T U V W X Y Z
#Observed letters = 1	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
#Observed letters = 4	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
#Observed letters = 8	R B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Ground truth	ABCDEFGHIJKLMNOPQRSTUVWXYZ
#Observed letters = 1	ABCDEFGHIJKLMNOPQRSTUVWXYZ
#Observed letters = 4	ABCDEFGHIJKLMNOPQRSTUVWXYZ
#Observed letters = 8	ABCDEFGHIJKLMNOPQRSTUVWXYZ
Ground truth #Observed letters = 1 #Observed letters = 4 #Observed letters = 8	ABCDEFGHIUKLMNDFOBSTUVWXYZ GCCCC3HIIINCUCPCCCCUCUNTZ ABCDEFGHIJKLMMOFOBSTUVJZZ ABCDEFGHIJKLMMOFOBSTUVJZZZ ABCDEFGHIKLMMOFOBSTUVJZZZ
Ground truth #Observed letters = 1 #Observed letters = 4 #Observed letters = 8	HBCDEFGHIJKLMNOPORSTUUWXYZ   ABCDEFGHIJKLMNOPORSTUVWXYZ   ABCDEFGHIJKLMNOPORSTUVWXYZ   ABCDEFGHIJKLMNOPORSTUVWXYZ   ABCDEFGHIJKLMNOPORSTUVWXYZ

Figure 6: Visualization comparison for our JointFontGAN model with different numbers of few-shot observed letters on Capitals64 dataset. The ground truth glyphs are shown in the 1st row. The 2nd, 3rd, 4th rows show the results with 1, 4, 8 observed references, respectively (marked in red boxes).

Ground truth MC-GAN Ours + Ornam. Network	A
Ground truth MC-GAN Ours + Ornam. Network	HECDEFEHIJKLMNDPDRSTUVWXYZRBDDEFEHIAKUKUAHDPDRSDUVMAYERBCDEFEHIJKLMNDPDRSTUDWXYZ
Ground truth MC-GAN Ours + Ornam. Network	ABCDEFGHIJKLMNOPURSTUVWXYZ ABCDEFGHIJKLMNOPURSTUVWXYZ XBCDEFGHIJKLMNOPURSTUVWXYZ

Figure 7: Visualization comparison for our JointFontGAN model + Ornamentation Network (without fine-tuning) on colored / ornamented glyphs of Capitals64 dataset. The ground truth glyphs and the few-shot reference sets (marked in red boxes) are shown in the 1st row. The 2nd row shows the results of MC-GAN [1]. The 3rd row shows the results of our model with Ornamentation Network.