RPG-Palm: Realistic Pseudo-data Generation for Palmprint Recognition

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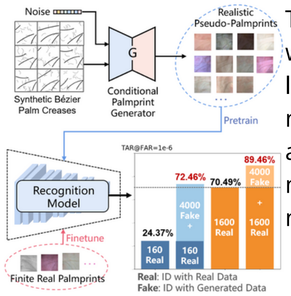
INTRODUCTION

Palmprint recognition offers a secure and privacy-friendly biometric solution, but its growth is hindered by the lack of large-scale, high-quality datasets. Traditional methods like BézierPalm and PalmGAN have tried to generate synthetic palmprints, yet they fall short: BézierPalm suffers from a domain gap with real palmprints, while PalmGAN fails to introduce new identities



To address these limitations, we introduce RPG-Palm (Realistic Pseudo-data Generation), a novel model that generates realistic and diverse palmprints while preserving identity consistency.

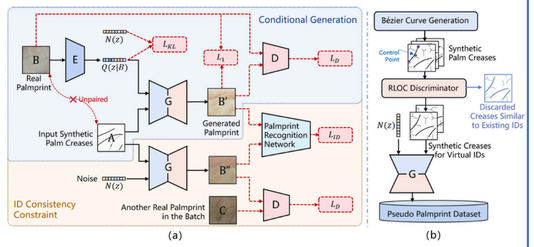
OBJECTIVES

- **Introduced RPG-Palm:** A realistic pseudo-palmprint generation model with a conditional modulation generator that enhances intra-class diversity and incorporates ID-aware loss to ensure identity consistency in unpaired training.
- **Enhanced Bézier Crease Synthesis:** Refined the Bézier curve synthesis to produce more realistic palm creases and ensure greater identity independence across synthetic samples.
- **Achieved State-of-the-Art Recognition:** Demonstrated through extensive testing on 13 public datasets that recognition models pretrained on RPG-Palm synthetic data outperform existing methods in accuracy.

METHOD

Whole framework of the proposed RPG model is on right, which includes a training stage (a) and a forward palmprint generation stage (b).

In the training stage, real palmprint images are encoded into a Gaussian noise vector through an encoder, which preserves essential features. The generator then takes unpaired synthetic Bézier palm creases as conditions and remaps the encoded noise back to the palmprint domain, generating diverse synthetic palmprints

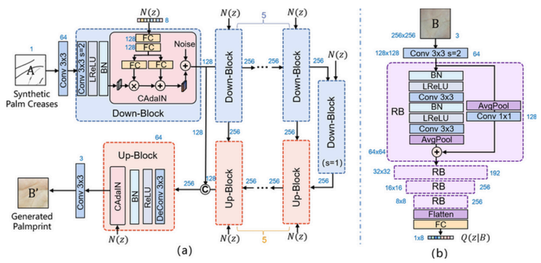


Conditional Modulation Structure

The generator uses a conditional modulation structure, which controls the modulation of intermediate features based on the input noise, creating variations in texture and lighting for realistic palmprints.

Palmprint Encoder

Maps palmprint images to a Gaussian noise domain, using a ResNet structure and a KL divergence loss to ensure stable and diverse latent representations for synthetic data generation



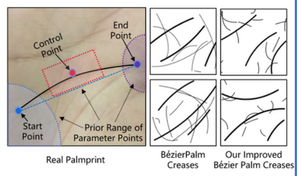
Identity-Aware Loss for Consistency

Enforces identity consistency by ensuring samples generated from the same input retain identical features, with a pretrained palmprint recognition discriminator checks the identity similarity between different samples generated from the same input

Improved Bézier Crease Generation

Enhances Bézier curve synthesis for realistic principal and wrinkle lines, ensuring inter-class diversity and distinctive patterns for each identity with the RLOC recognition method

Comparison of BézierPalm (left) and our improved synthetic creases (right). Our method refines control points for realistic principal and wrinkle lines, closely resembling real palmprints and ensuring unique identity patterns



RESULTS

Generated Bézier Creases and corresponding generated palmprints using RPG model:

Method	Backbone	train : test = 1 : 1				train : test = 1 : 3			
		TAR@ 1e-3	TAR@ 1e-4	TAR@ 1e-5	TAR@ 1e-6	TAR@ 1e-3	TAR@ 1e-4	TAR@ 1e-5	TAR@ 1e-6
C-LMCL [71]	MB	0.9290	0.8554	0.7732	0.6239	0.8509	0.7554	0.7435	0.5932
ArcFace [14]	MB	0.9292	0.8568	0.7812	0.7049	0.8516	0.7531	0.6608	0.5825
BézierPalm [69]	MB	0.9640	0.9438	0.9102	0.8437	0.9407	0.8861	0.7934	0.7012
Ours	MB	**0.9802**	**0.9714**	**0.9486**	**0.8946**	**0.9496**	**0.9267**	**0.8969**	**0.8485**
C-LMCL [71]	R50	0.9545	0.9027	0.8317	0.7534	0.8601	0.7701	0.6821	0.6254
ArcFace [14]	R50	0.9467	0.8925	0.8252	0.7462	0.8709	0.7884	0.7156	0.6580
BézierPalm [69]	R50	0.9671	0.9521	0.9274	0.8956	0.9424	0.8950	0.8217	0.7649
Ours	R50	**0.9821**	**0.9732**	**0.9569**	**0.9347**	**0.9533**	**0.9319**	**0.9016**	**0.8698**

Here, MB=MobileFaceNet and R50=resnet50 backbones

Resnet50 and MobileFaceNet recognisation Model used as backbone. Our method outperforms BézierPalm by 5.09% and 14.73% under 1:1 and 1:3 settings @FAR=1e-6 using 'MB'

Generated palmprint images of different methods, (a) pix2pixHD, (b) CycleGAN, (c) BicycleGAN, (d) the proposed method

Pix2pixHD and CycleGAN often produce blurred outputs, while BicycleGAN may generate creases that don't align with the input Bézier curves. In contrast, our method produces clear, sharp principal lines and consistently preserves the identity information of the input curves