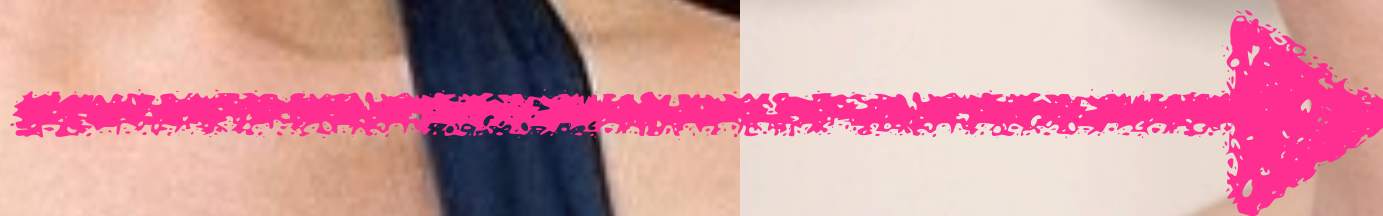


ExprGAN: Facial Expression Editing with Controllable Expression Intensity

Hui Ding, Kumar Sricharan, Rama Chellappa



AAAI 2018



Need of Paired Training Data



Source



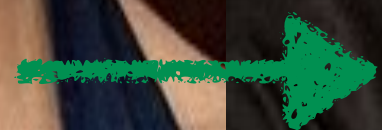
Target

Yeh, Raymond, Ziwei Liu, Dan B. Goldman, and Aseem Agarwala.
"Semantic facial expression editing using autoencoded flow." arXiv preprint
arXiv:1611.09961 (2016).

Low Resolution



Cheung, Brian, Jesse A. Livezey, Arjun K. Bansal, and Bruno A. Olshausen.
"Discovering hidden factors of variation in deep networks." ICLR workshop
(2014).



Weak intensity



Strong Intensity

Will the synthetic face images
be useful for the expression
classifier?

Expression GAN

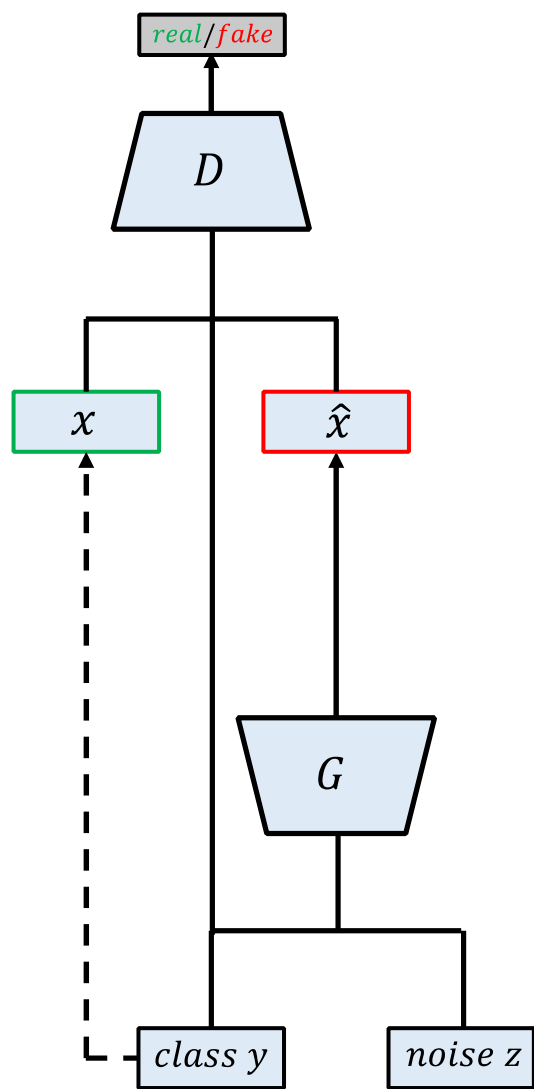
- **First** GAN-based model for facial expression editing

Controllable Expression Intensity

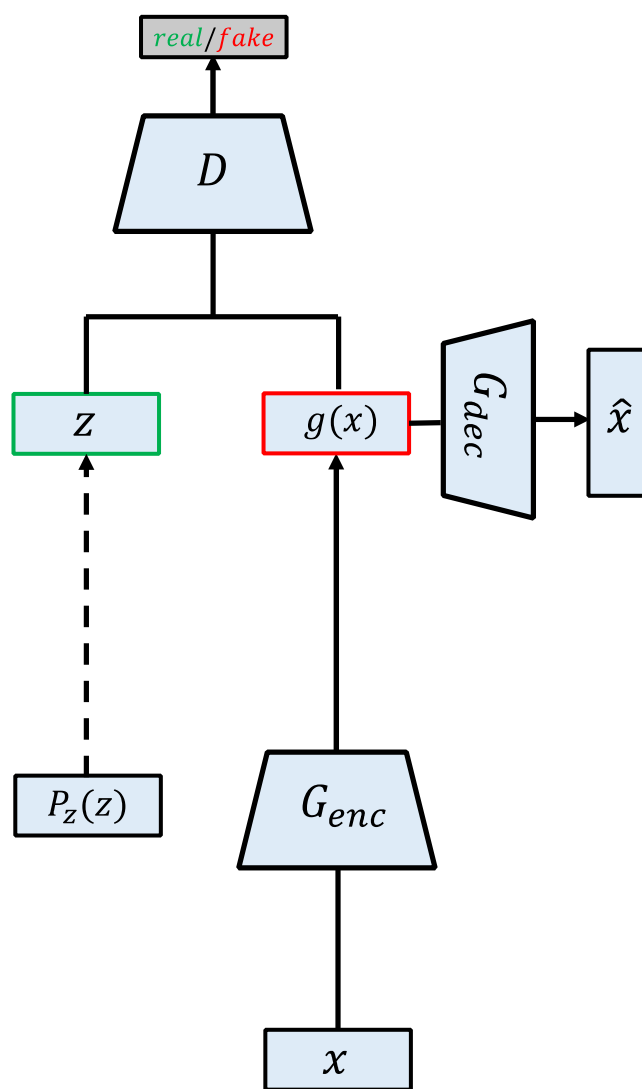
Synthetic Face Image for Data Augmentation

Disentangled Identity and Expression Representation

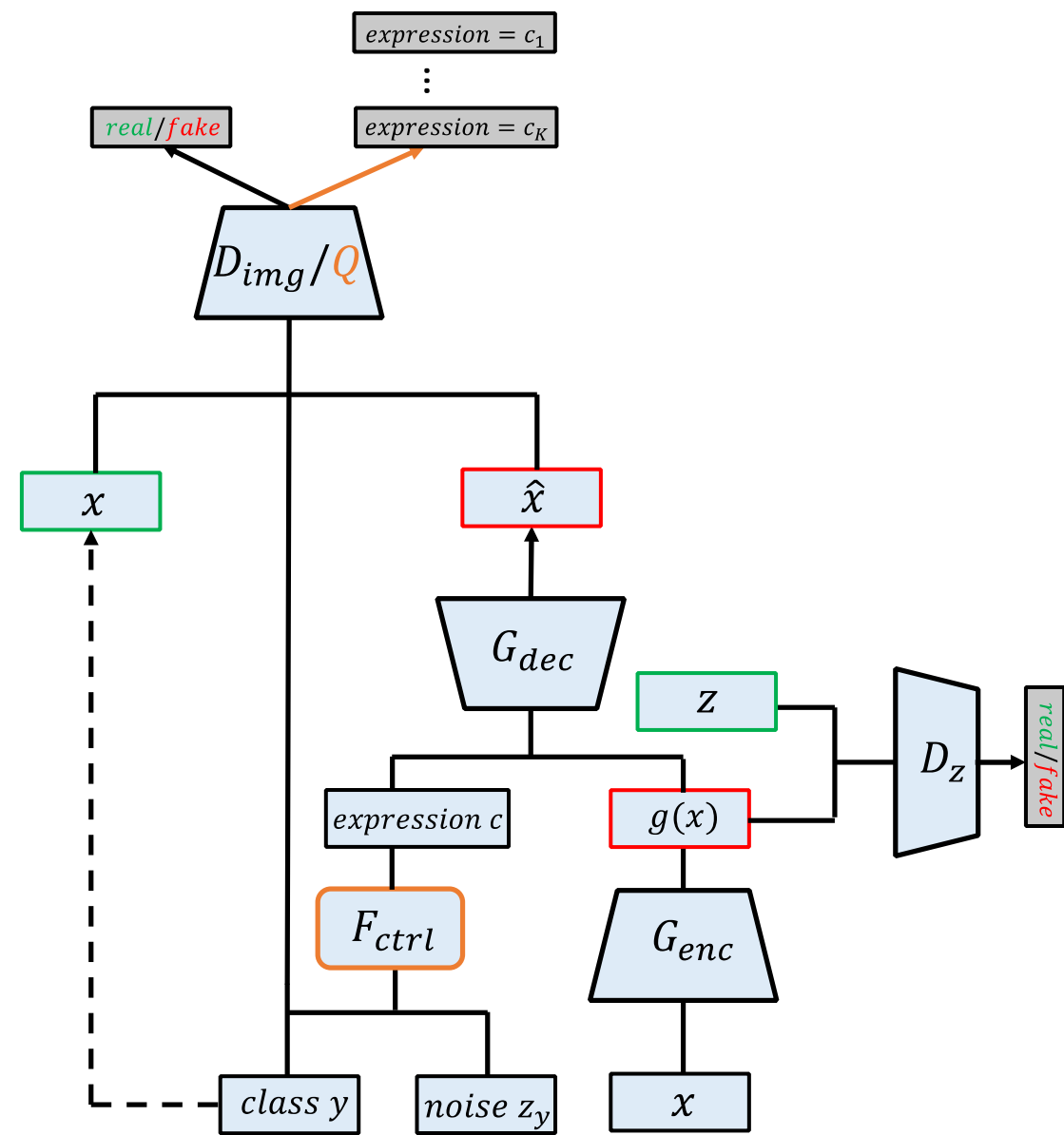
Curriculum Training for Limited Training Data



(a) Conditional GAN

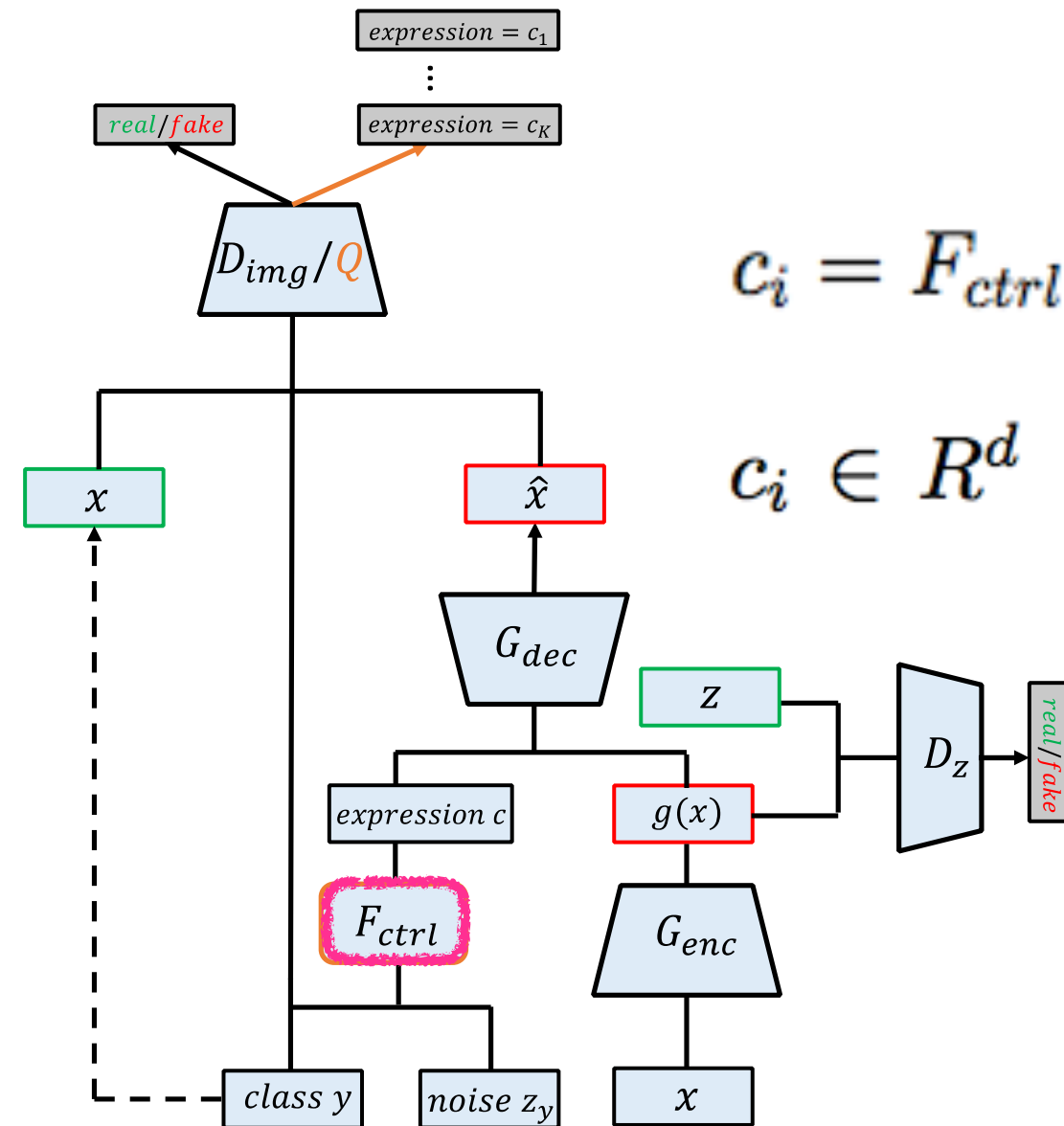


(b) Adversarial Autoencoder



(c) ExprGAN

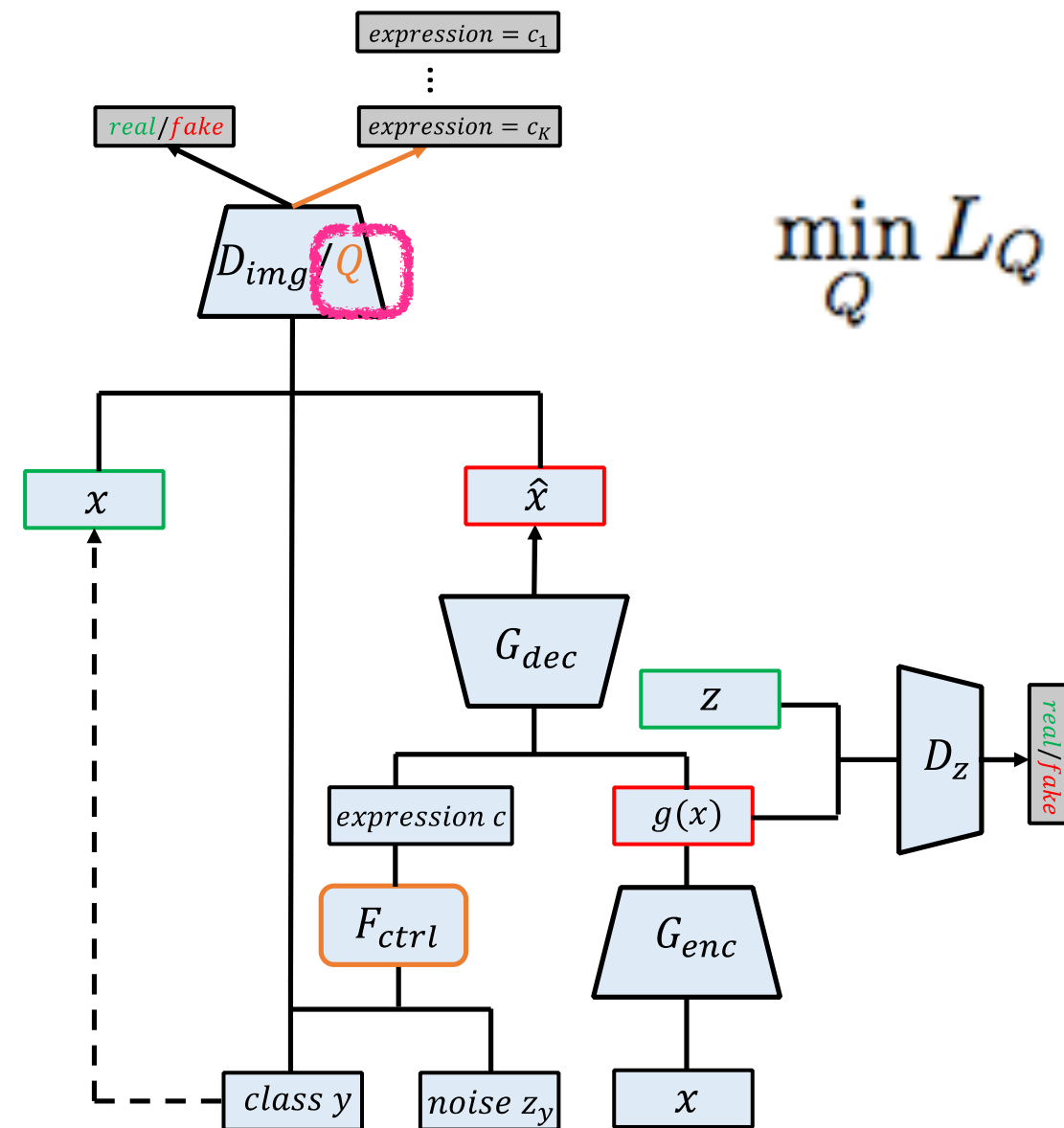
Expression Controller Module



$$c_i = F_{ctrl}(y_i, z_y) = |z_y| \cdot (2y_i - 1) \quad i = 1, 2, \dots, K$$

$$c_i \in R^d$$

Expression Regularization Network



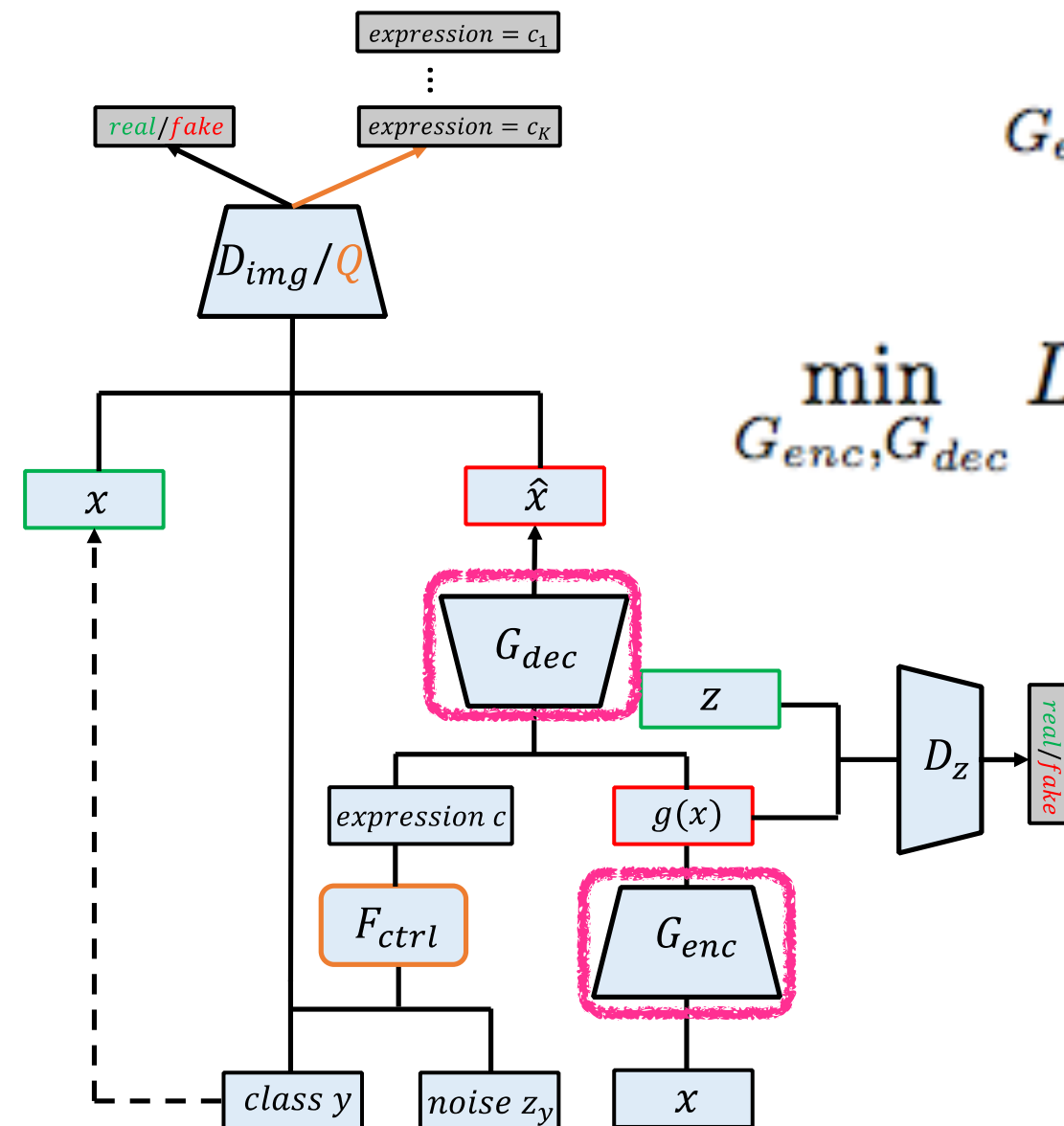
$$\min_Q L_Q = -\mathbb{E}_{c \sim P(c|y), \hat{x} \sim G_{dec}(g(x), c)} [\log Q(c|\hat{x}, y)]$$

$$\begin{aligned} I(c; \hat{x}|y) &= H(c|y) - H(c|\hat{x}, y) \\ &= \mathbb{E}_{\hat{x} \sim G_{dec}(g(x), c)} [\mathbb{E}_{c' \sim P(c'|\hat{x}, y)} [\log P(c'|\hat{x}, y)]] + H(c|y) \\ &= \mathbb{E}_{\hat{x} \sim G_{dec}(g(x), c)} [D_{KL}(P(\cdot|\hat{x}, y) || Q(\cdot|\hat{x}, y)) + \mathbb{E}_{c' \sim P(c'|\hat{x}, y)} [\log Q(c'|\hat{x}, y)]] + H(c|y) \\ &\geq \mathbb{E}_{\hat{x} \sim G_{dec}(g(x), c)} [\mathbb{E}_{c' \sim P(c'|\hat{x}, y)} [\log Q(c'|\hat{x}, y)]] + H(c|y) \\ &= \mathbb{E}_{c \sim P(c|y), \hat{x} \sim G_{dec}(g(x), c)} [\log Q(c|\hat{x}, y)] + H(c|y) \end{aligned}$$

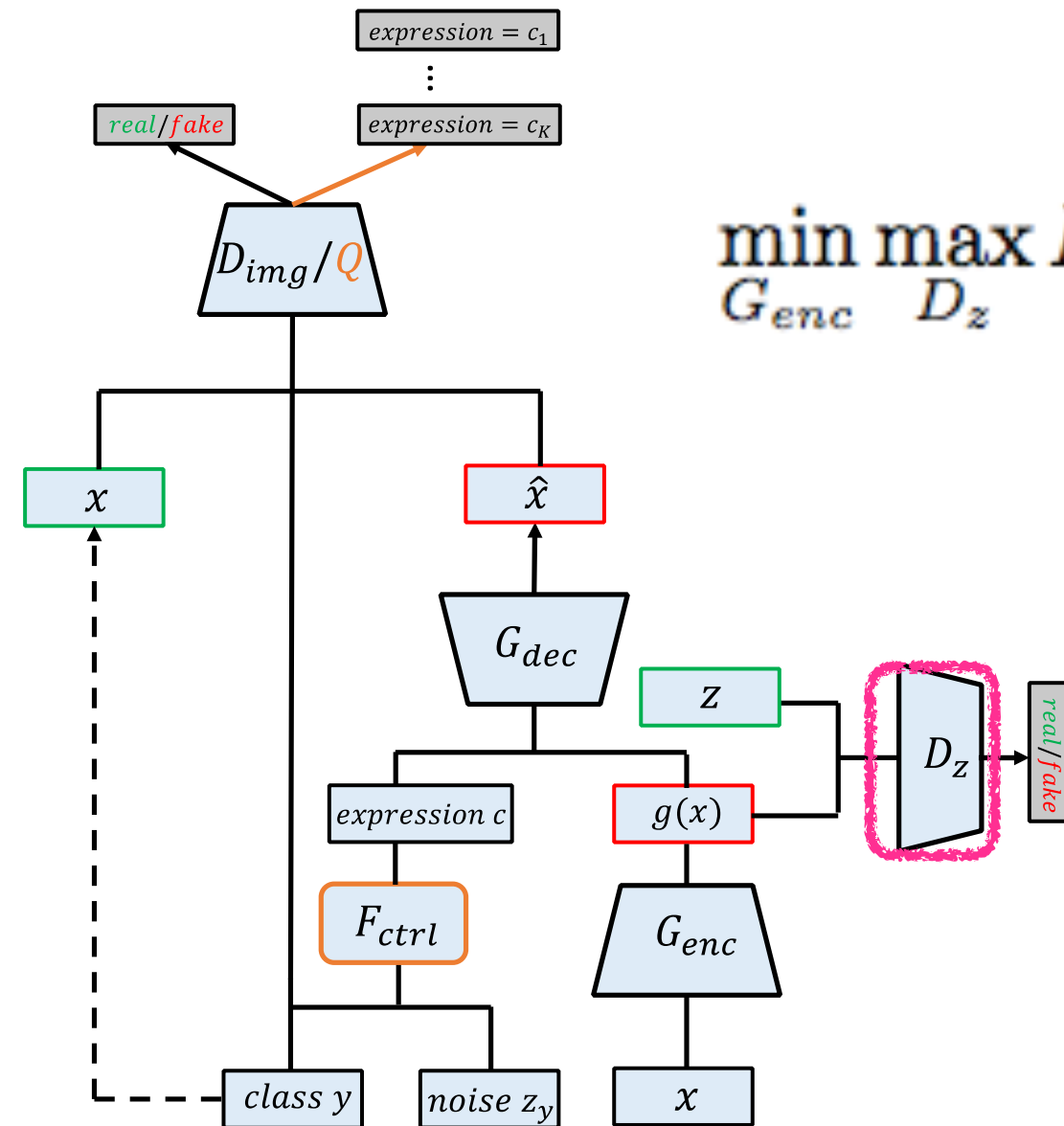
Generator Network

$$\min_{G_{enc}, G_{dec}} L_{pixel} = L_1(G_{dec}(G_{enc}(x), c), x)$$

$$\min_{G_{enc}, G_{dec}} L_{id} = \sum_l \beta_l L_1(\phi_l(G_{dec}(G_{enc}(x), c)), \phi_l(x))$$



Discriminator on Identity Representation



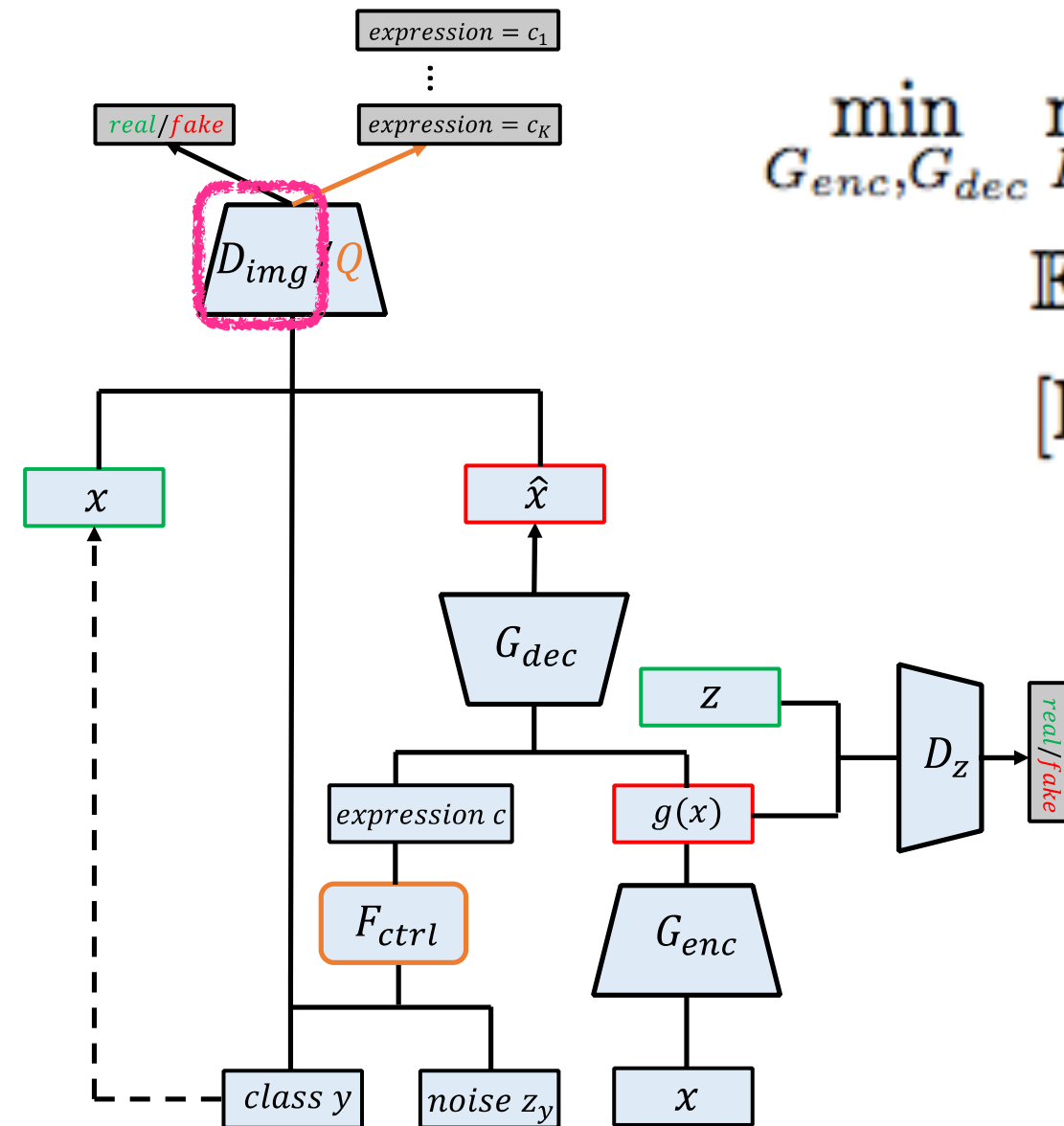
$$\min_{G_{enc}} \max_{D_z} L_{adv}^z = \mathbb{E}_{z \sim P_z(z)} [\log D_z(z)] + \mathbb{E}_{x \sim P_{data}(x)} [\log(1 - D_z(G_{enc}(x)))]$$

Discriminator on Image

$$\min_{G_{enc}, G_{dec}} \max_{D_{img}} L_{adv}^{img} = \mathbb{E}_{x, y \sim P_{data}(x, y)} [\log D_{img}(x, y)] +$$

$$\mathbb{E}_{x, y \sim P_{data}(x, y), z_y \sim P_{z_y}(z_y)}$$

$$[\log(1 - D_{img}(G_{dec}(G_{enc}(x), F_{ctrl}(z_y, y)), y))]$$



Overall Objective Function

$$\min_{G_{enc}, G_{dec}, Q} \max_{D_{img}, D_z} L_{ExprGAN} = L_{pixel} + \lambda_1 L_{id} + \lambda_2 L_Q \\ + \lambda_3 L_{adv}^{img} + \lambda_4 L_{adv}^z + \lambda_5 L_{tv}$$

Limited Training Data?

Curriculum Training

Controller Learning Stage

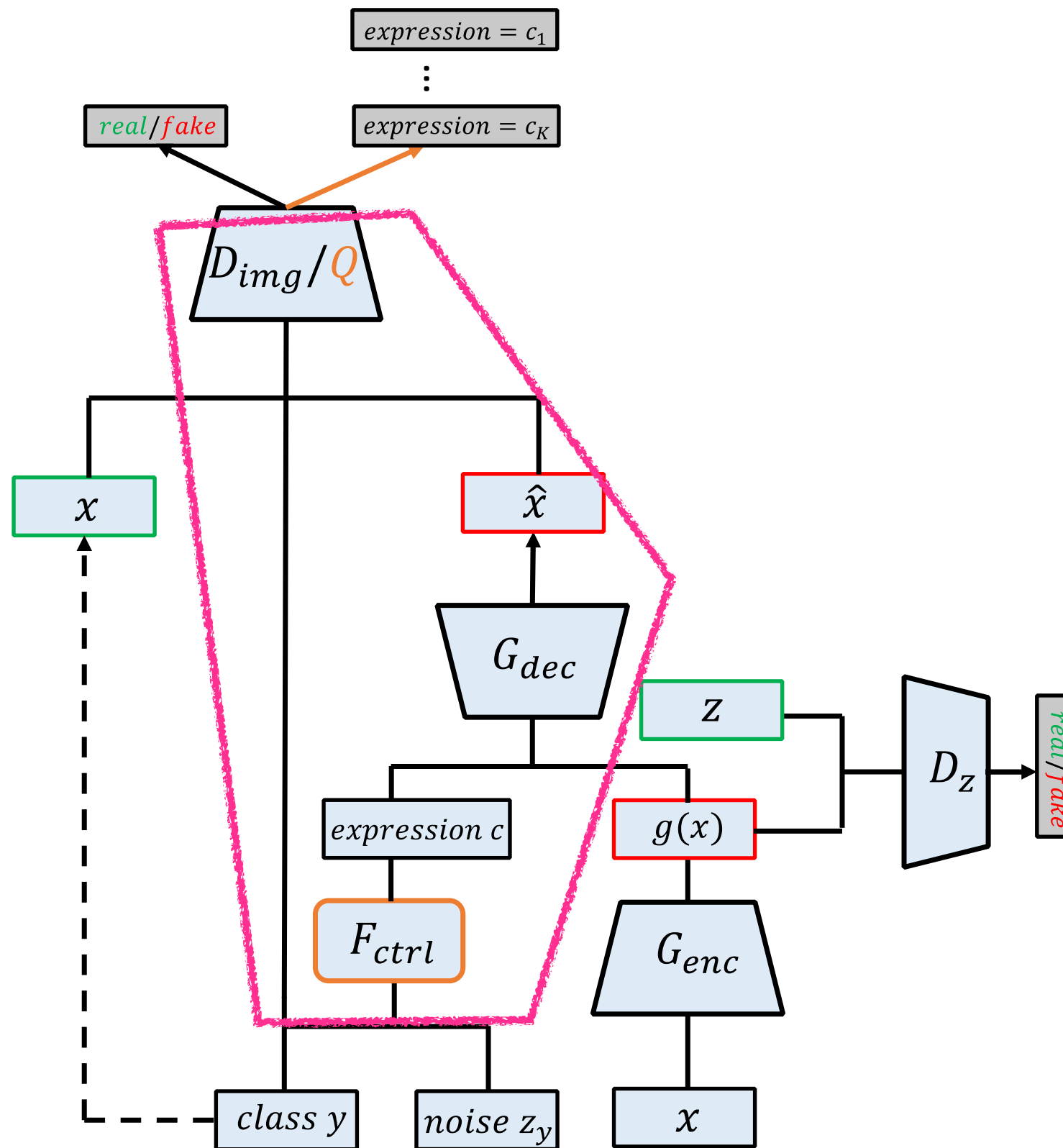


Image Reconstruction Stage

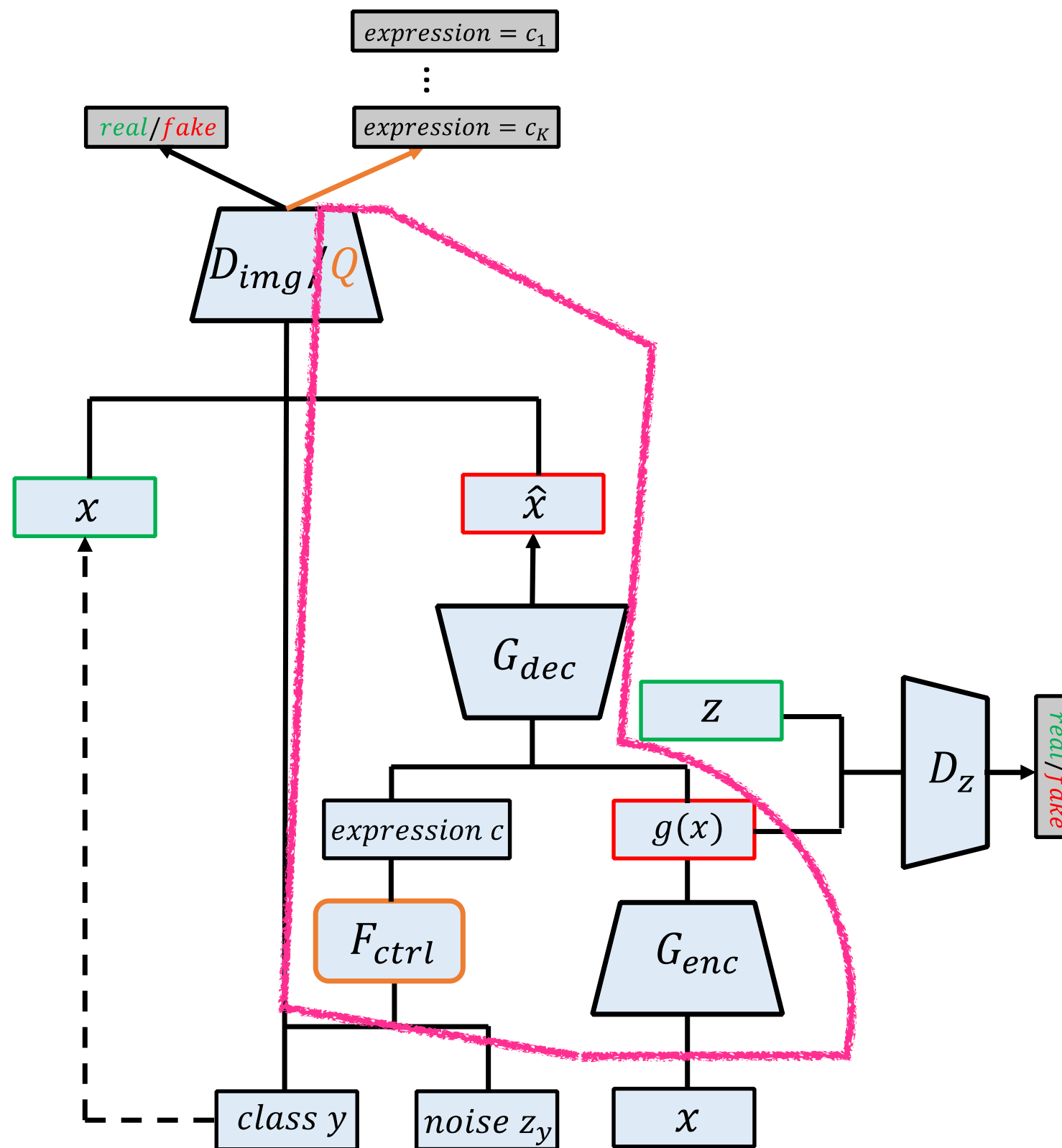
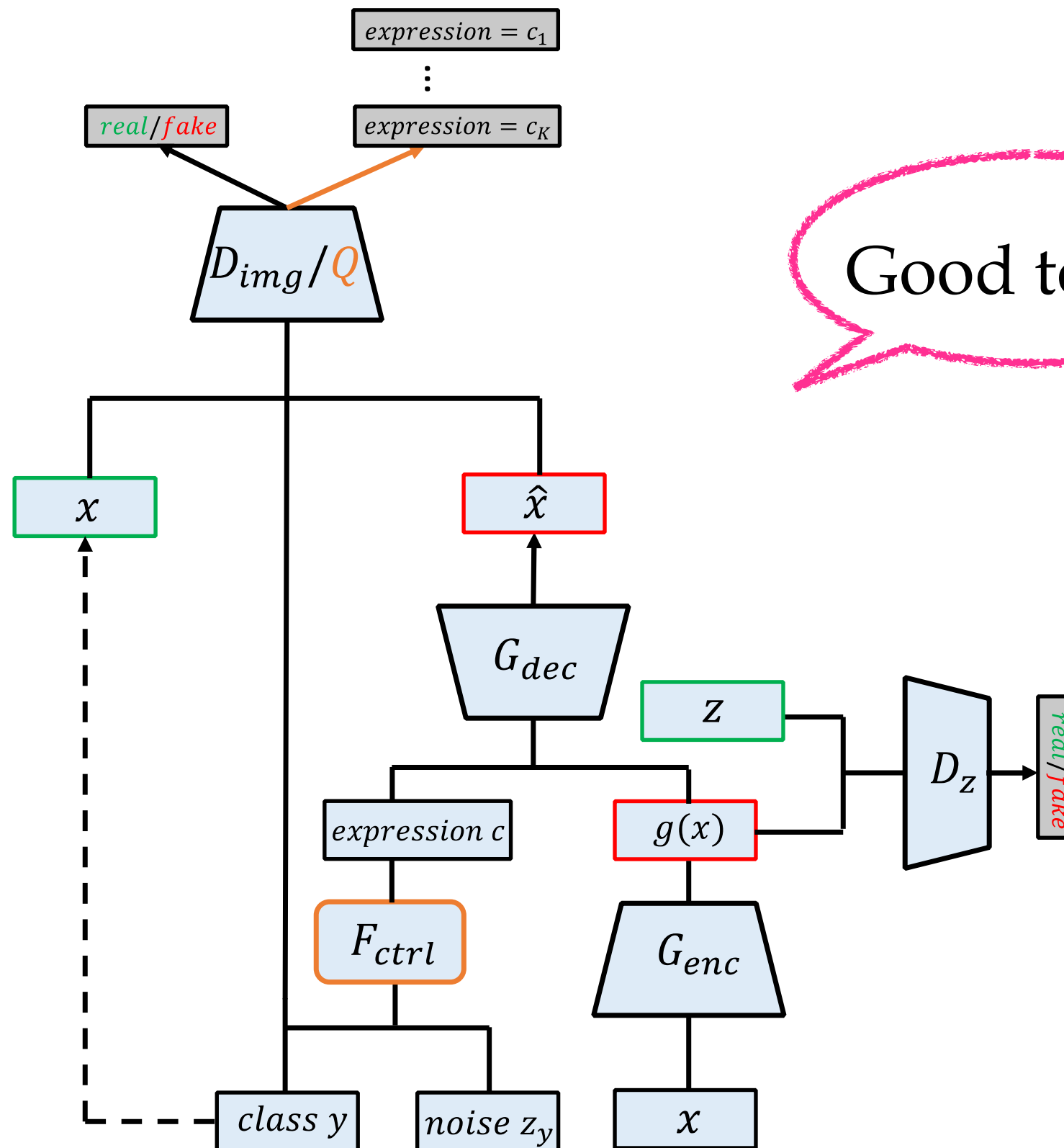


Image Refining Stage

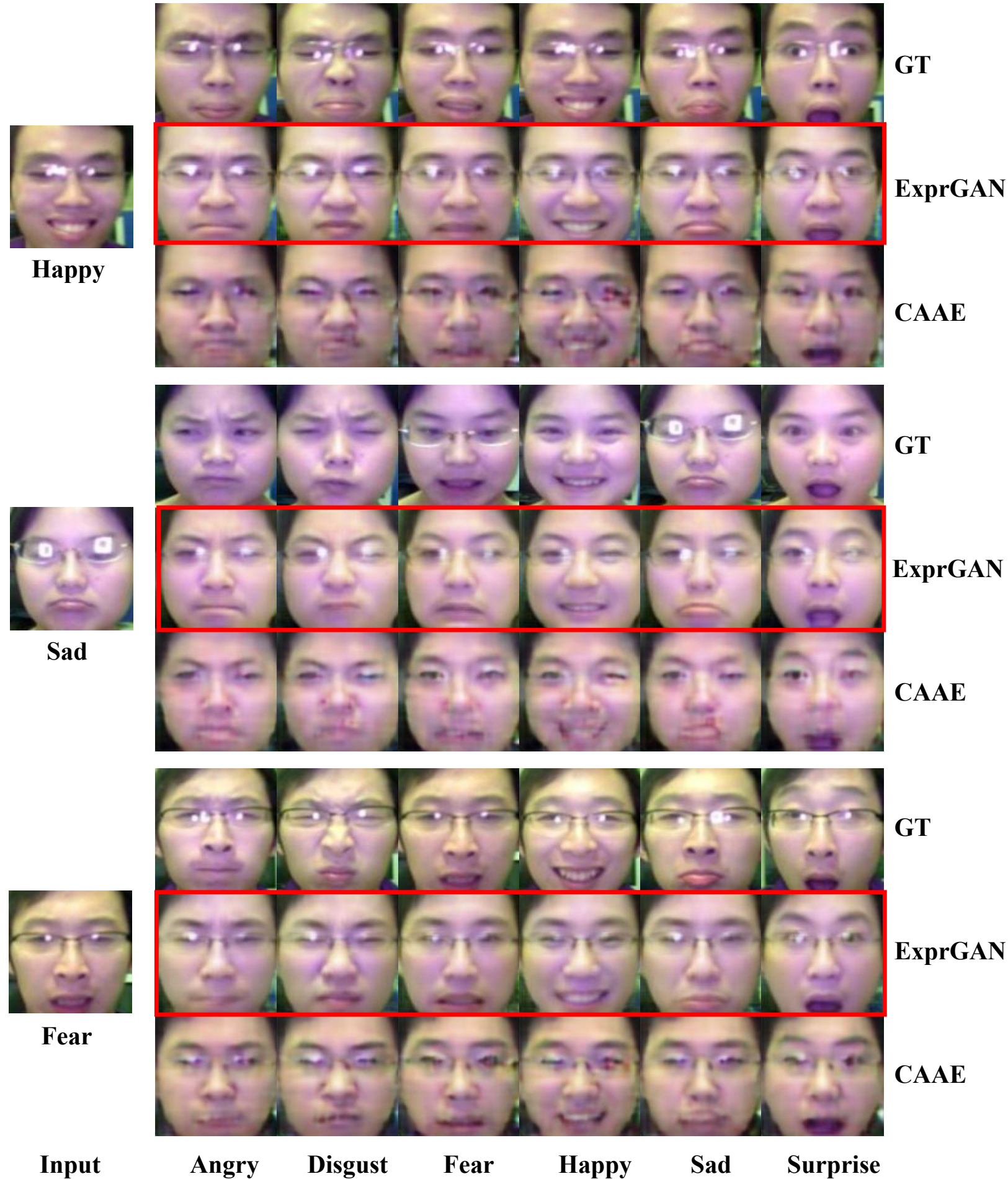


Good to Go!

Experiments

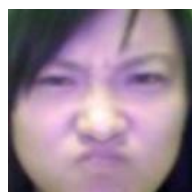
	An	Co	Di	Fe	Ha	Sa	Su	Ne	Total
Oulu-CASIA	240		240	240	240	240	240		1444

Expression Editing

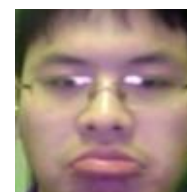


Zhang, Zhifei, Yang Song, and Hairong Qi. "Age Progression/Regression by Conditional Adversarial Autoencoder." CVPR 2017.

Expression Editing with Controllable Intensity



Disgust



Sad

Weak



Strong



Angry

Disgust

Fear

Happy

Sad

Surprise

Neutral



Angry

Disgust

Fear

Happy

Sad

Surprise

Neutral

Expression Transfer



IdA

ExprB

IdA+ExprB



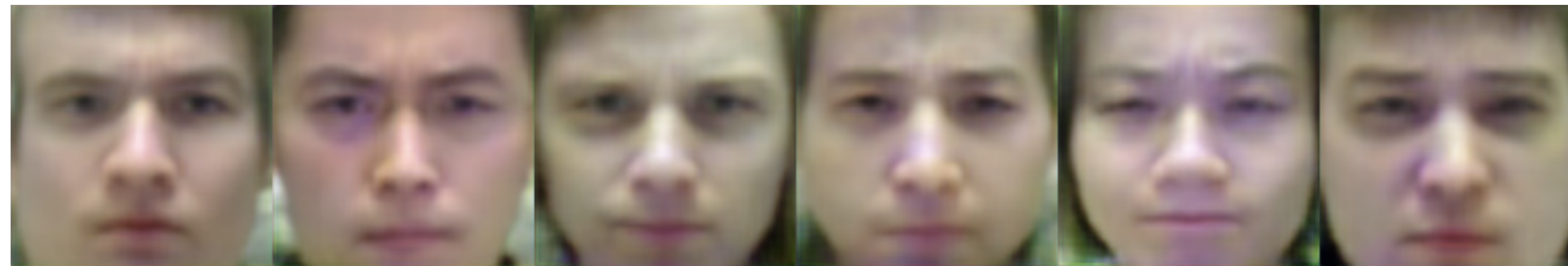
IdA

ExprB

IdA+ExprB

Synthetic Images for Data Augmentation

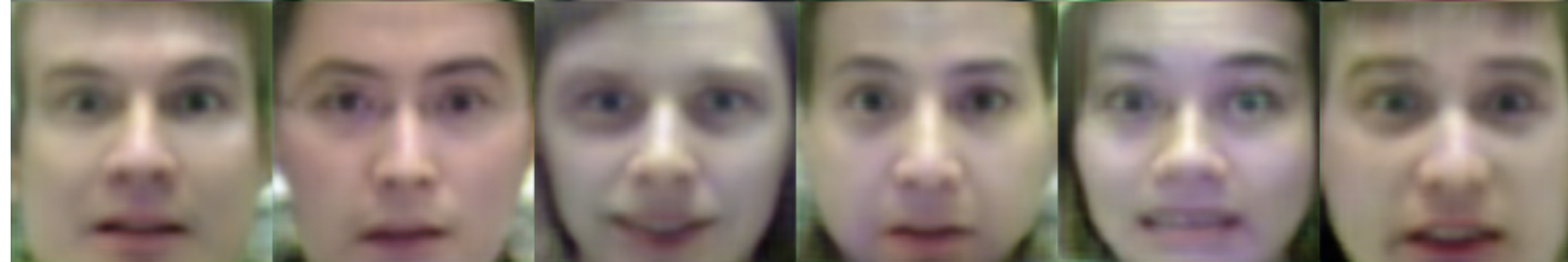
Disgust



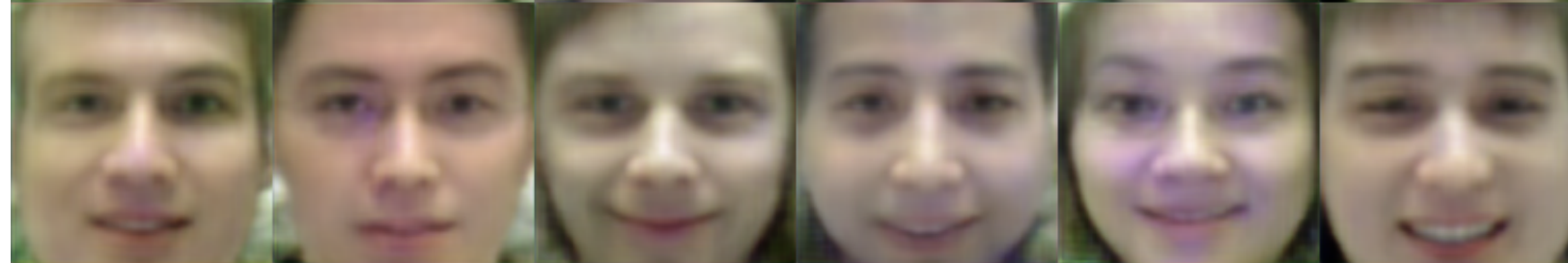
Angry



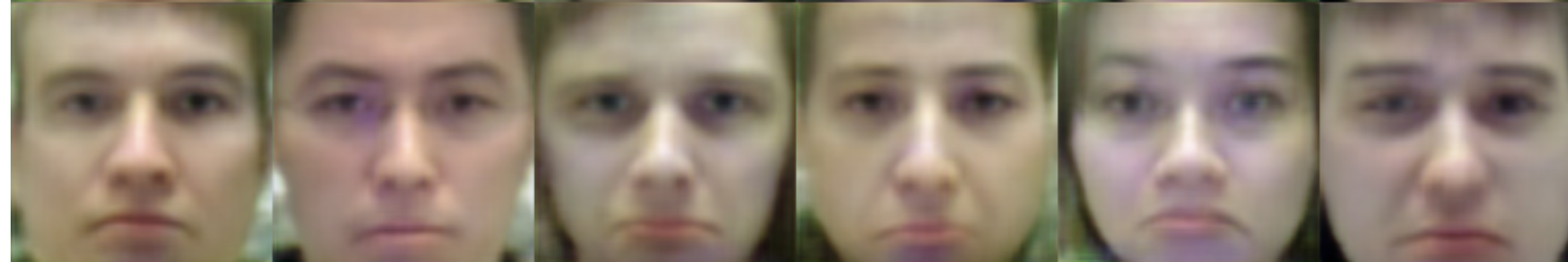
Fear



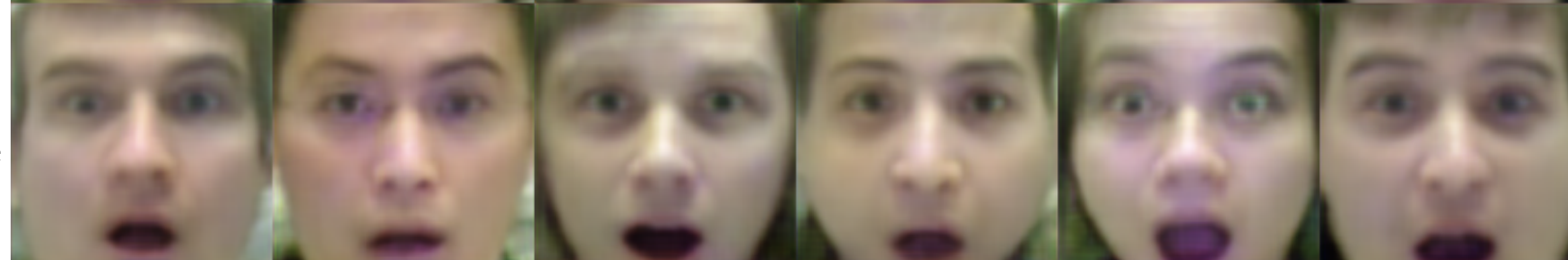
Happy



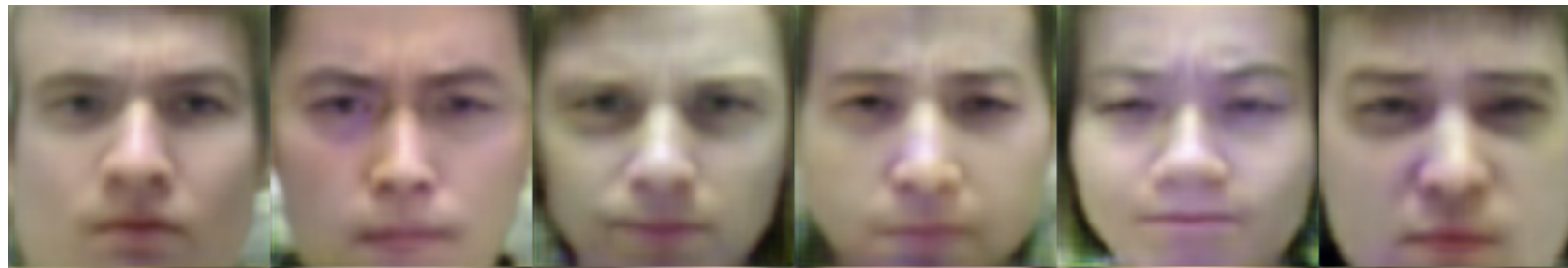
Sad



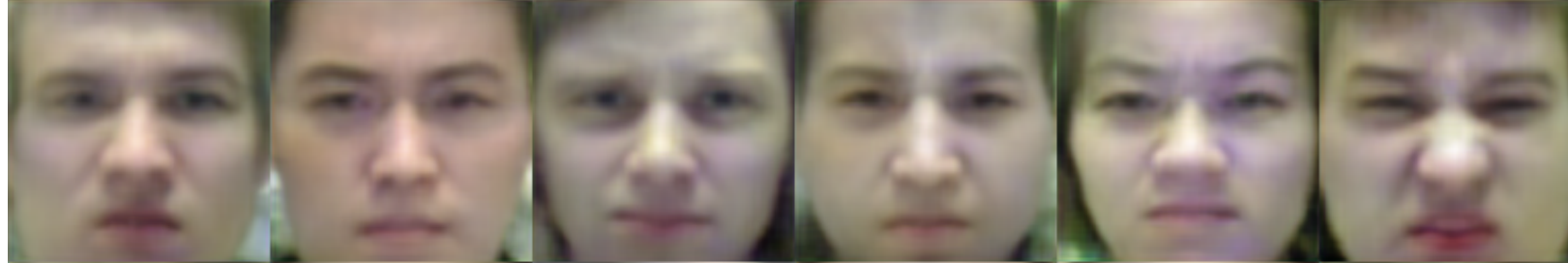
Surprise



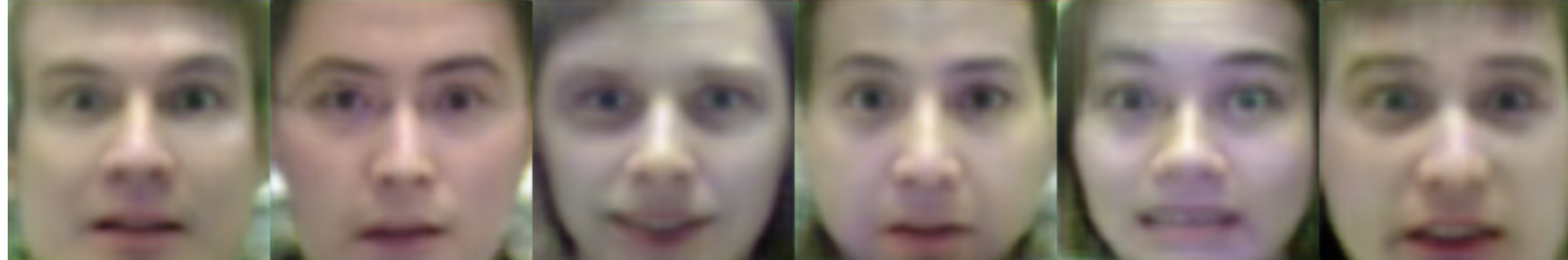
Disgust



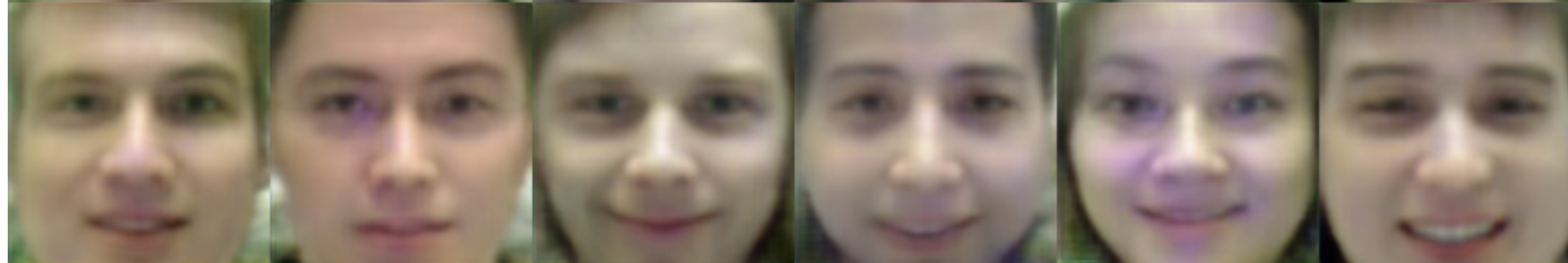
Angry



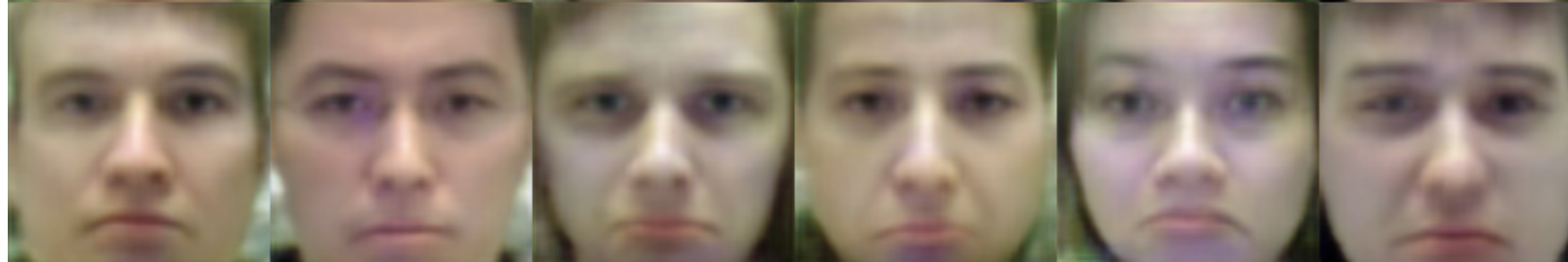
Fear



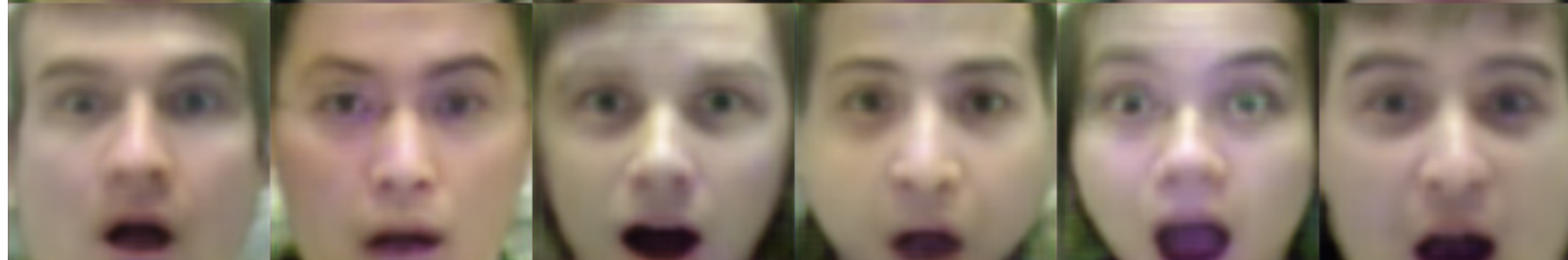
Happy



Sad

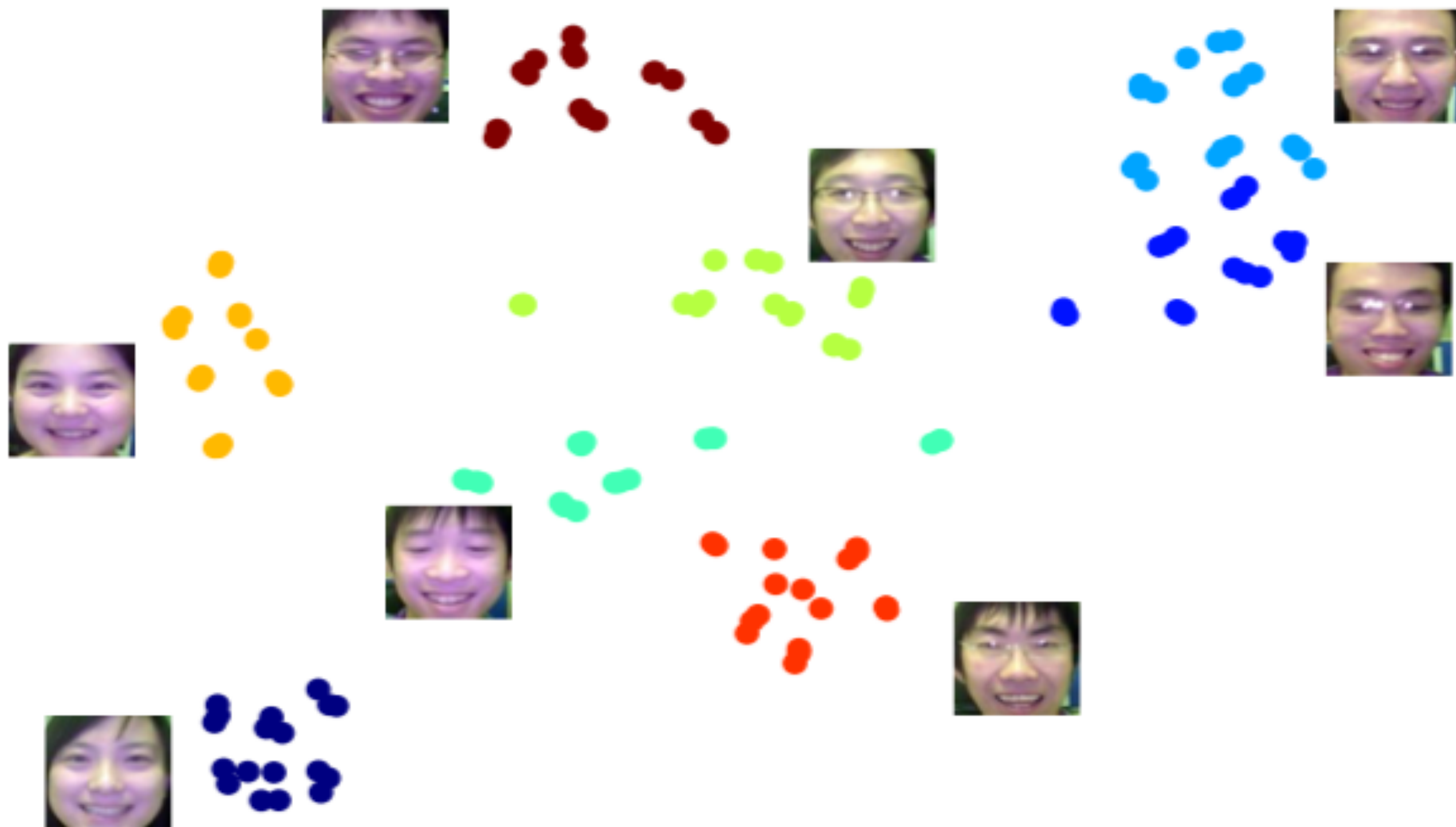


Surprise



# Syn. Images	0	3K	6K	30K	60K
Accuracy (%)	77.78	78.47	81.94	84.72	84.72

Identity Feature Visualization



Expression Feature Visualization



Query

c

y

x

Thank You

Code and model:

<https://github.com/HuiDingUMD/ExprGAN>