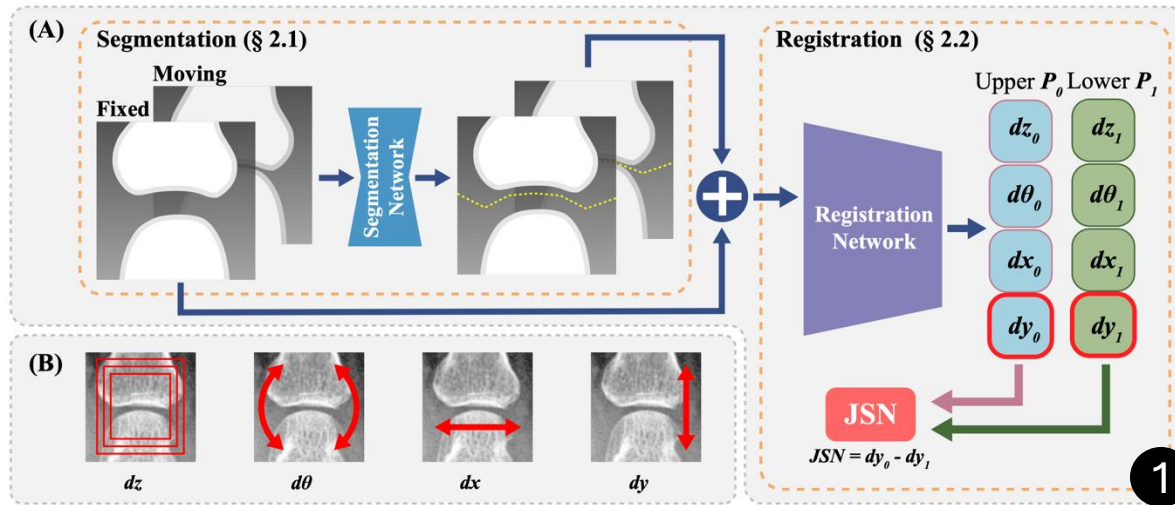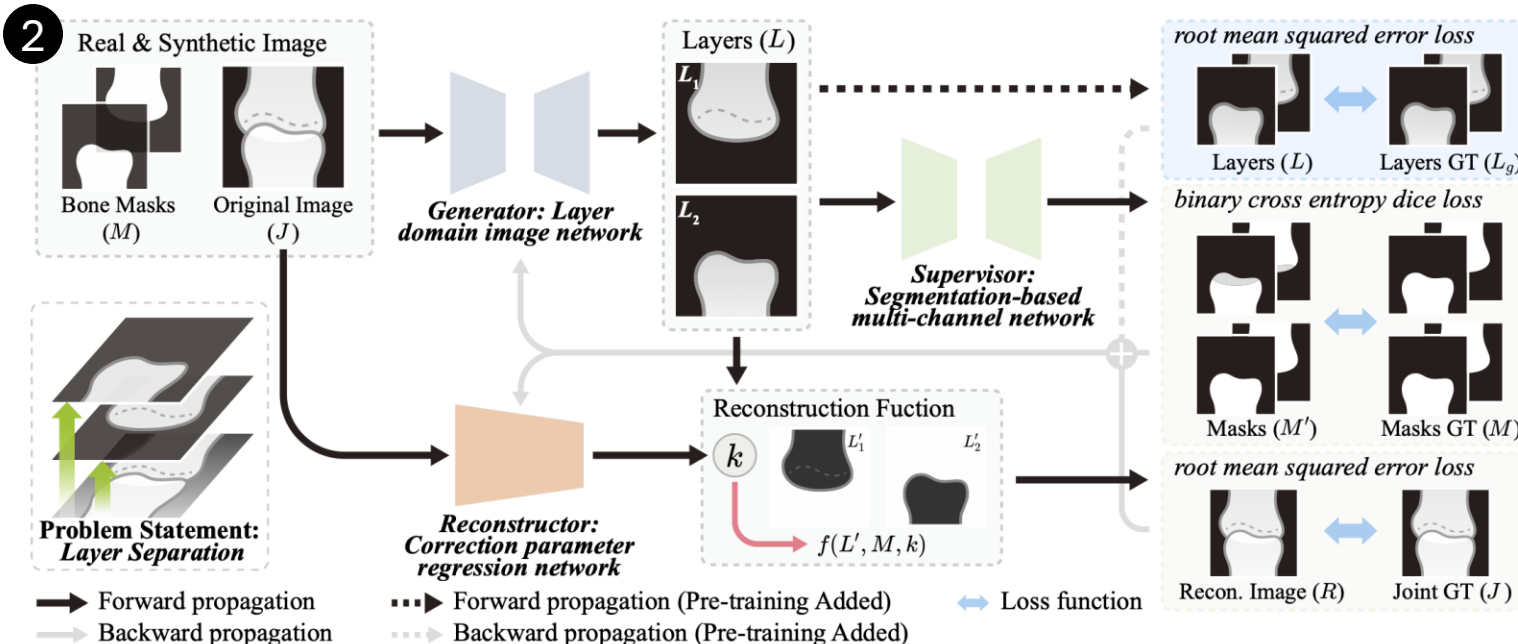# A Deep Learning Framework for Accurate Quantification of Joint Space Narrowing Progression in Rheumatoid Arthritis

(1) Deep Registration: Based on deep image registration, achieve high-precision and high-stability quantification of JSN progression.

(2) Layer Separation (BLS-GAN): Generate bone layer domain image based on a single X-ray finger joint image and eliminate bone overlaps.

(A) Segmentation (§ 2.1) — Moving, Fixed — Segmentation Network — Registration (§ 2.2) — Upper P_0 Lower P_1 — Registration Network — dz_0 dz_1 — $d\theta_0$ $d\theta_1$ — dx_0 dx_1 — dy_0 dy_1 — JSN — $JSN = dy_0 - dy_1$

(B) dz $d\theta$ dx dy

2 Real & Synthetic Image — Bone Masks (M) — Original Image (J) — *Generator: Layer domain image network* — Layers (L) — L_1 L_2 — *Supervisor: Segmentation-based multi-channel network* — *root mean squared error loss* — Layers (L) ⟷ Layers GT (L_g) — *binary cross entropy dice loss* — Masks (M') ⟷ Masks GT (M) — *root mean squared error loss* — Recon. Image (R) ⟷ Joint GT (J)

Problem Statement: Layer Separation — *Reconstructor: Correction parameter regression network* — Reconstruction Fuction — k — L'_1 L'_2 — $f(L', M, k)$

Forward propagation — Forward propagation (Pre-training Added) — Loss function
Backward propagation — Backward propagation (Pre-training Added)

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