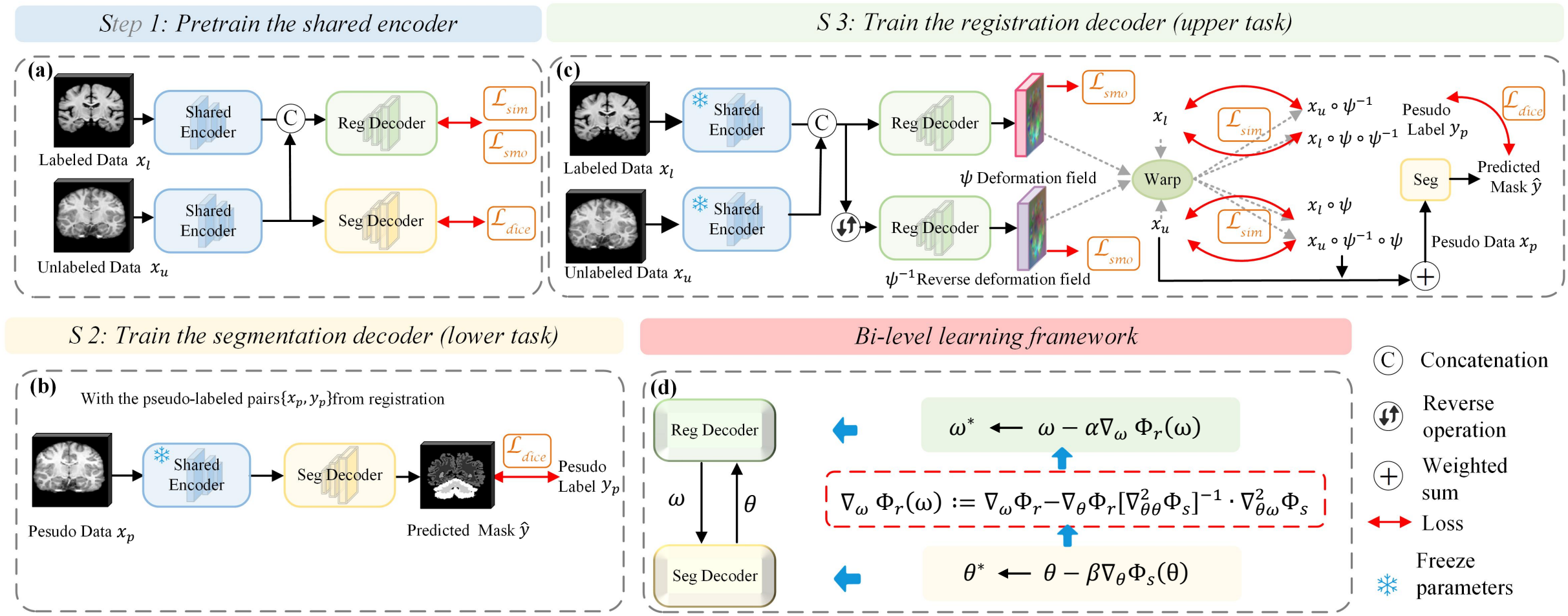
Step 1: Pretrain the shared encoder
S 3: Train the registration decoder (upper task)
(a)
Labeled Data x_l
Shared Encoder
C
Reg Decoder
$\mathcal{L}_{sim}$
$\mathcal{L}_{smo}$
Unlabeled Data x_u
Shared Encoder
Seg Decoder
$\mathcal{L}_{dice}$
(c)
Labeled Data x_l
Shared Encoder
C
Reg Decoder
$\mathcal{L}_{smo}$
ψ Deformation field
Unlabeled Data x_u
Shared Encoder
Reg Decoder
ψ^{-1} Reverse deformation field
$\mathcal{L}_{smo}$
x_l
Warp
x_u
$\mathcal{L}_{sim}$
$x_u \circ \psi^{-1}$
$x_l \circ \psi \circ \psi^{-1}$
$\mathcal{L}_{sim}$
$x_l \circ \psi$
$x_u \circ \psi^{-1} \circ \psi$
Pesudo Label y_p
$\mathcal{L}_{dice}$
Seg
Predicted Mask $\hat{y}$
Pesudo Data x_p
S 2: Train the segmentation decoder (lower task)
Bi-level learning framework
(b)
With the pseudo-labeled pairs$\{x_p, y_p\}$from registration
Shared Encoder
Seg Decoder
$\mathcal{L}_{dice}$
Pesudo Label y_p
Pesudo Data x_p
Predicted Mask $\hat{y}$
(d)
Reg Decoder
ω
θ
Seg Decoder
$\omega^* \leftarrow \omega - \alpha \nabla_\omega \Phi_r(\omega)$
$\nabla_\omega \Phi_r(\omega) := \nabla_\omega \Phi_r - \nabla_\theta \Phi_r [\nabla^2_{\theta\theta} \Phi_s]^{-1} \cdot \nabla^2_{\theta\omega} \Phi_s$
$\theta^* \leftarrow \theta - \beta \nabla_\theta \Phi_s(\theta)$
C Concatenation
Reverse operation
Weighted sum
Loss
Freeze parameters