Recurrent Registration Neural Networks for Deformable Image Registration: Supplementary Material

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1 Supplementary Material

In this document, we present additional information and results of the R2N2 registration algorithm.

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2 Network Training

Algorithm 1 shows an overview of the training procedure of the presented *Recurrent Registration Neural Network* (R2N2).

Algorithm 1 Training procedure of the R2N2

$\theta \leftarrow$ Initialize network parameters
$i \leftarrow 0$
for i $<$ number of training iterations **do**
  $M_i, F_i \leftarrow$ Sample image pair from training set
  $f_0 \leftarrow 0$ Initialize transformation
  $\mathcal{L}_\mathcal{S} \leftarrow 0$ Initialize sequence image loss
  $W_0 \leftarrow M_i$
  $t \leftarrow 1$
  for t $<$ number of max transformations T **do**
    $g_t \leftarrow \text{R2N2}(F_i, W_{t-1}, \theta)$ Evaluate model
    $f_t \leftarrow f_{t-1} + l(g_t)$ Update transformation
    $W_t \leftarrow M_i \circ f_t$ Transform M_i
    $\mathcal{L}_\mathcal{S} \leftarrow \mathcal{L}_\mathcal{S} + \mathcal{S}[F_i, W_t]$ Calculate image loss
    $t \leftarrow t + 1$
  end for
  $\mathcal{L}_\mathcal{R} \leftarrow \mathcal{R}[f_T]$ Calculate regularizer loss
  $\mathcal{L} \leftarrow \mathcal{L}_\mathcal{S} + \lambda\mathcal{L}_\mathcal{R}$ Final loss
  Compute the gradient $\frac{\partial \mathcal{L}}{\partial_\theta}$
  Update the network parameters θ
  $i \leftarrow i + 1$
end for

3 Results

In the following, we show detailed results of the presented *Recurrent Registration Neural Network* for the registration of one image pair. Figure 3-7 visualize the input and output of the R2N2 at each time step t during the registration. We can observe a decreasing tendency of the shape parameter σ_t (Figure 1) and the weight parameter v_t (Figure 2) during the registration. That shows that our network achieves a coarse correction of large misalignments during the first steps and then continues with the finer ones. This registration procedure is very similar to how a human would align two images by applying a sequence of local deformations. The difference between the weight value v_x and the weight value v_x (Figure 2) can be explained by the fact that the major misalignment of the lung images are evoked by the breathing motion of the patient, which is oriented along the $y-$direction.

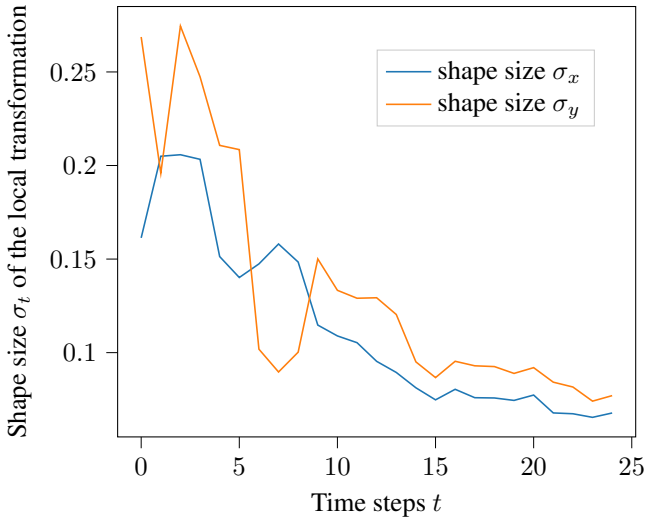

Figure 1: Shape size σ_x and σ_y of the local transformation outputted by the R2N2 at each time step t for one image pair.

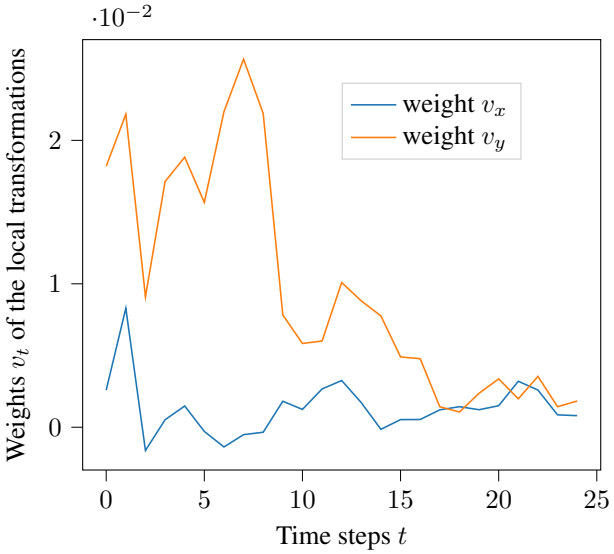

Figure 2: Wights v_x and v_y of the local transformation outputted by the R2N2 at each time step t for one image pair.

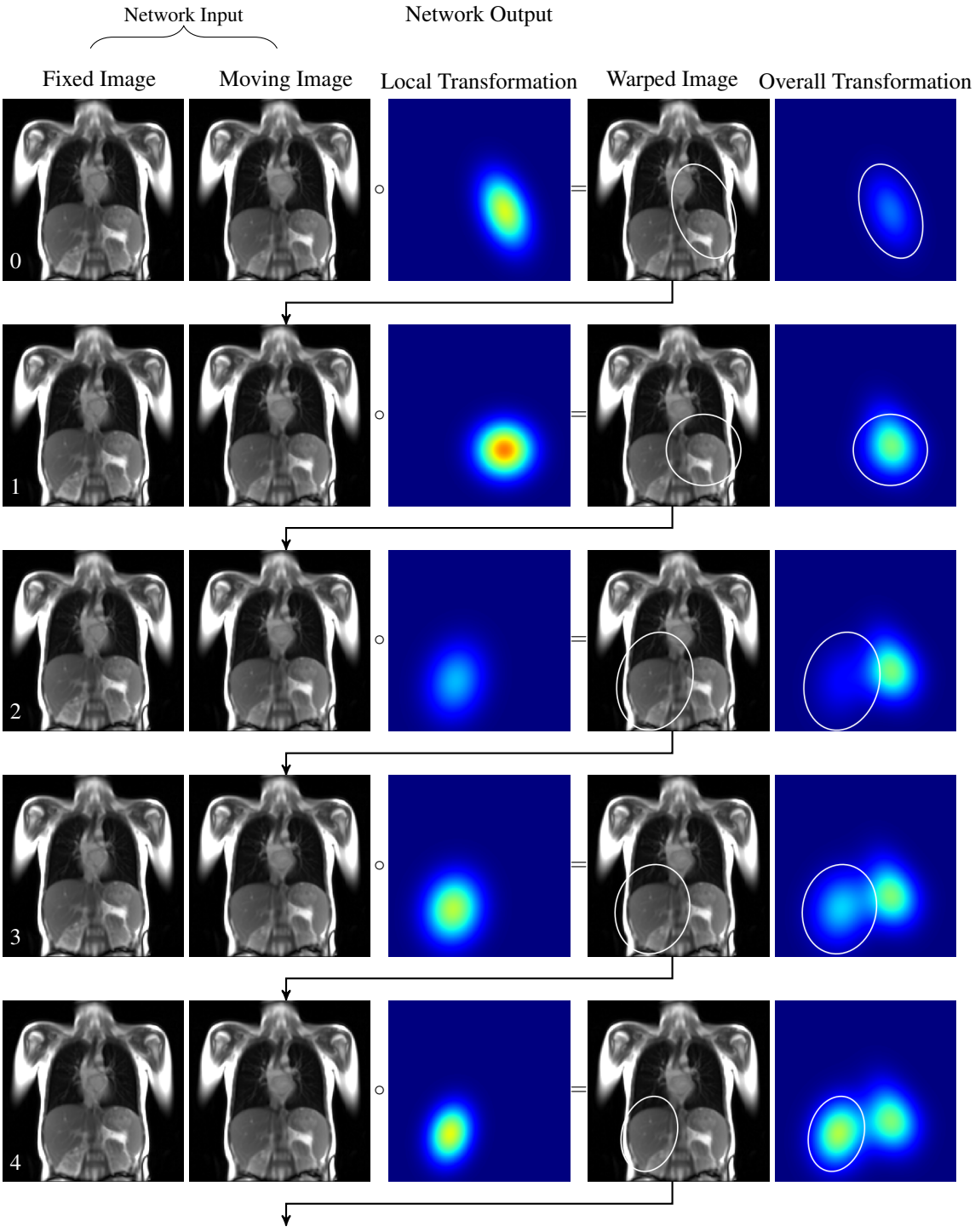

Figure 3: Input and output for the R2N2 network for the time steps $0 - 4$ during the registration of one image pair. Here, $\circ$ is the transformation of the image on the left side with the transformation on the right side.

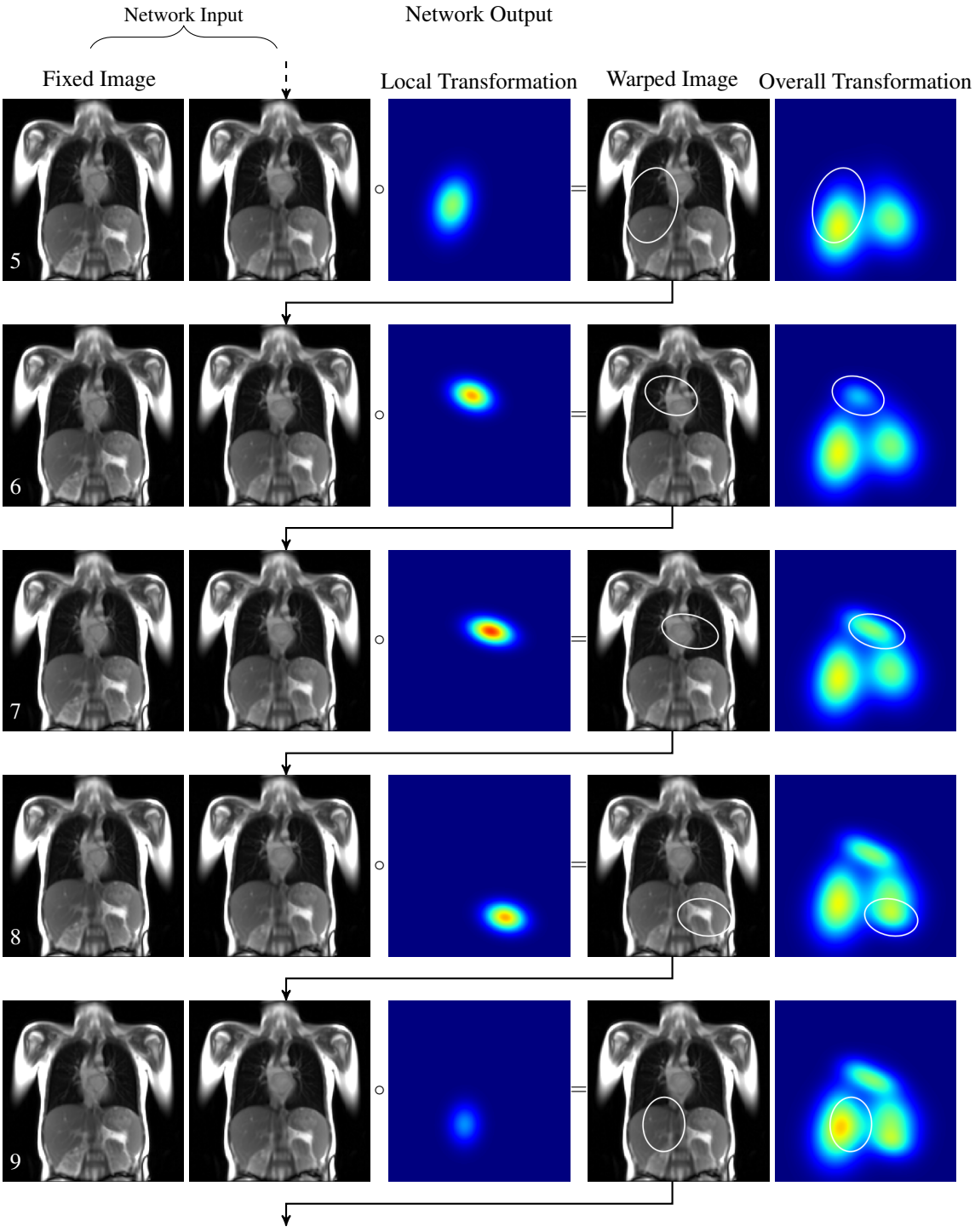

Figure 4: Input and output for the R2N2 network for the time steps $5 - 9$ during the registration of one image pair. Here, $\circ$ is the transformation of the image on the left side with the transformation on the right side.

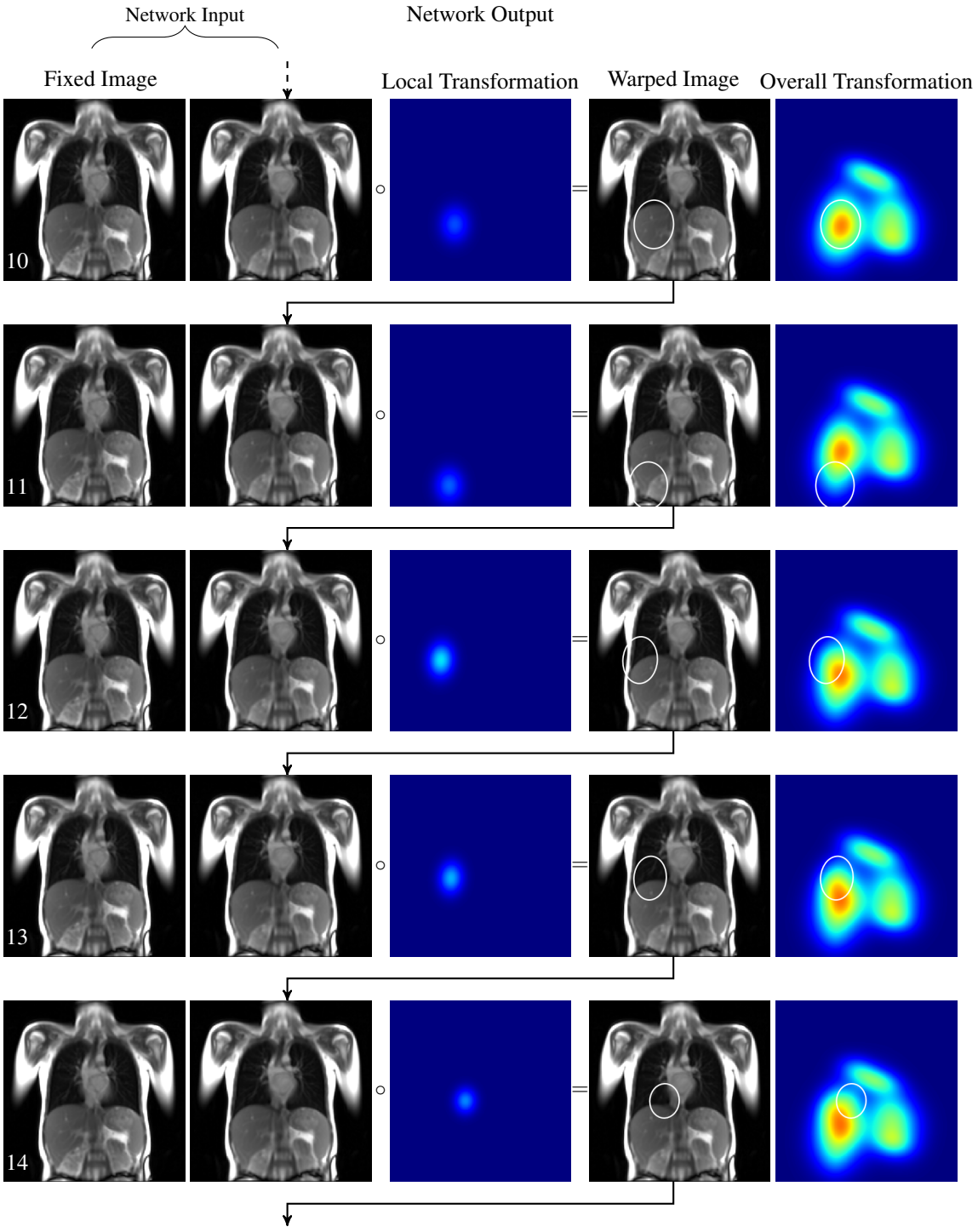

Figure 5: Input and output for the R2N2 network for the time steps $10 - 14$ during the registration of one image pair. Here, $\circ$ is the transformation of the image on the left side with the transformation on the right side.

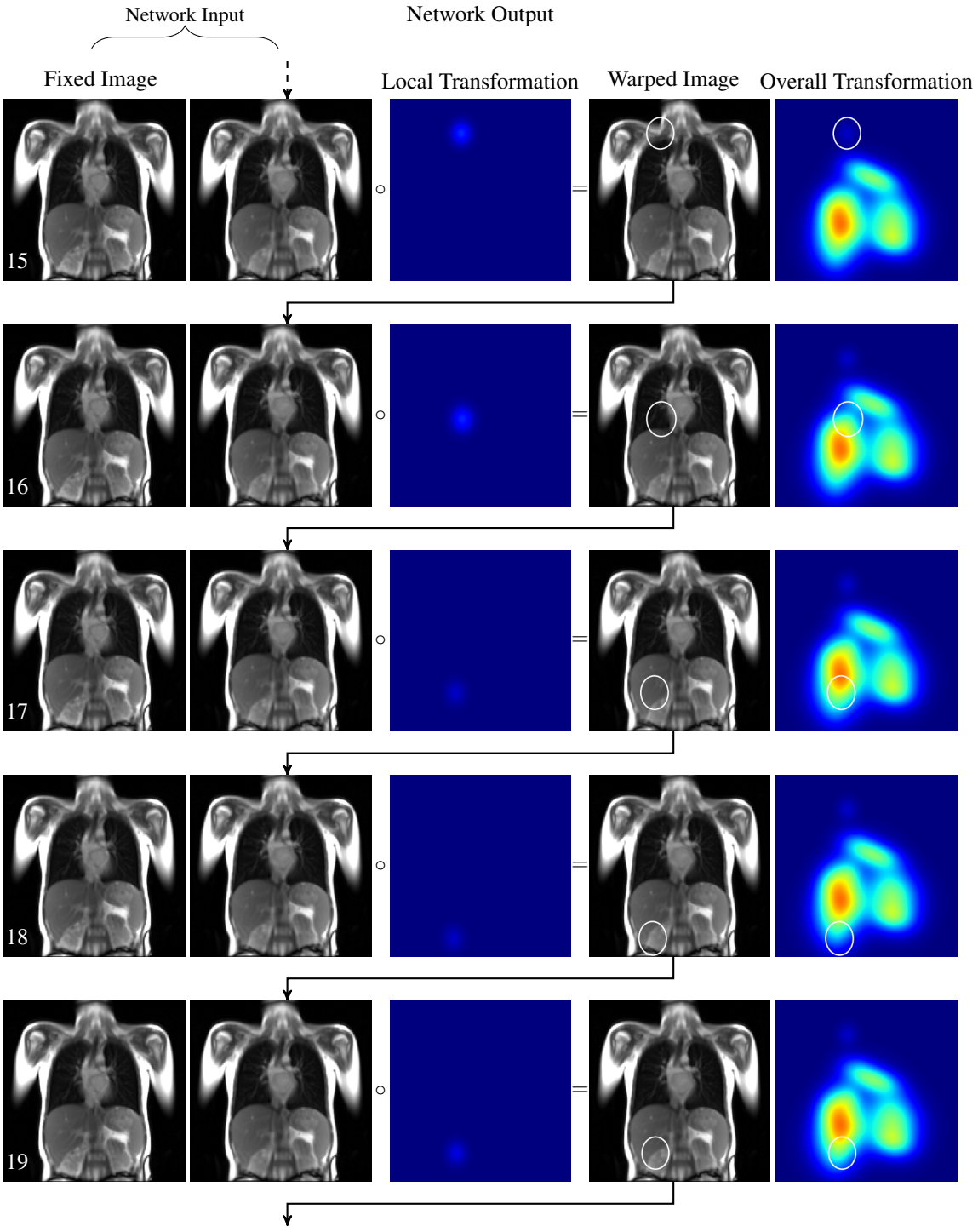

Figure 6: Input and output for the R2N2 network for the time steps $15 - 19$ during the registration of one image pair. Here, $\circ$ is the transformation of the image on the left side with the transformation on the right side.

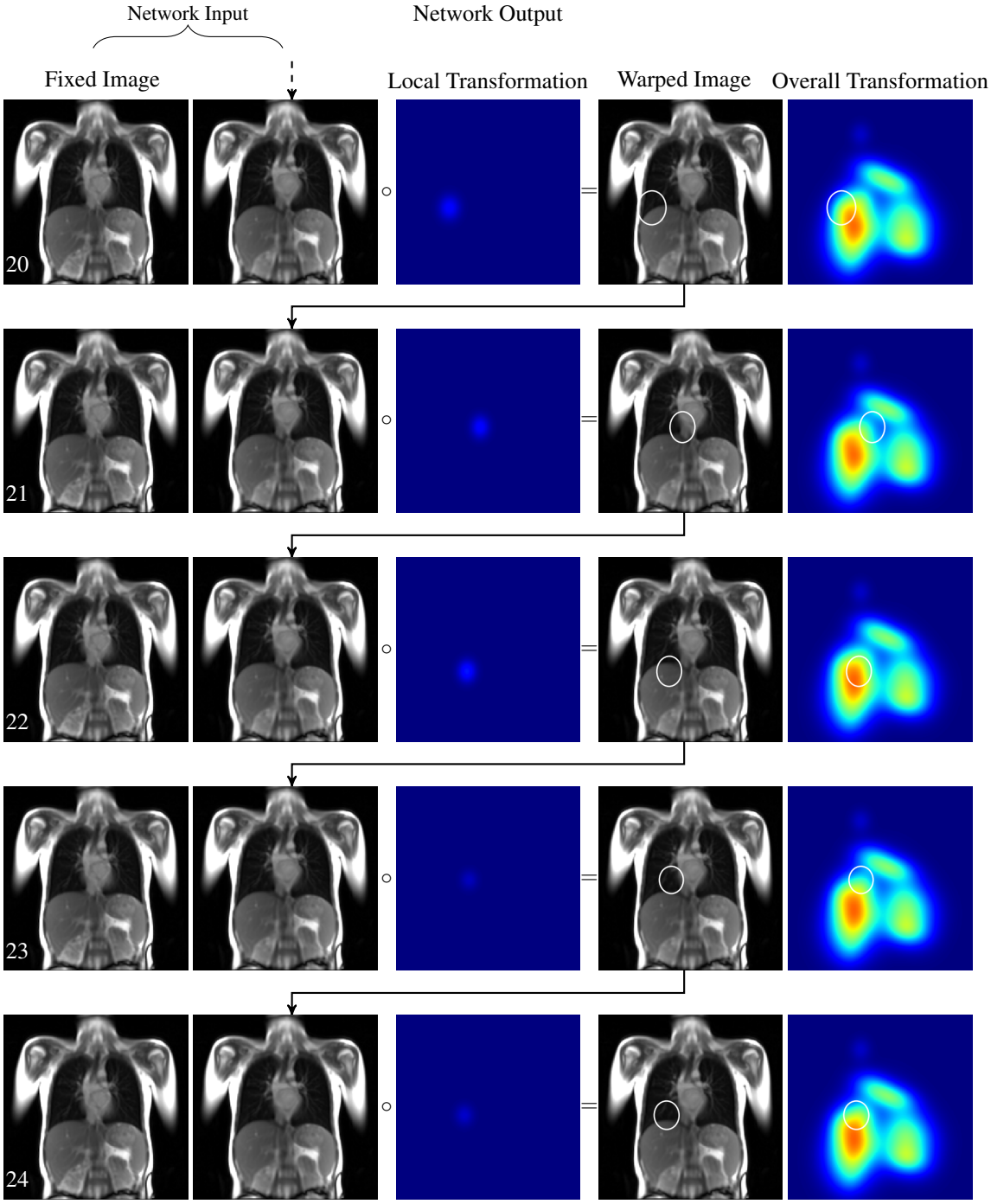

Figure 7: Input and output for the R2N2 network for the time steps $20 - 24$ during the registration of one image pair. Here, $\circ$ is the transformation of the image on the left side with the transformation on the right side.