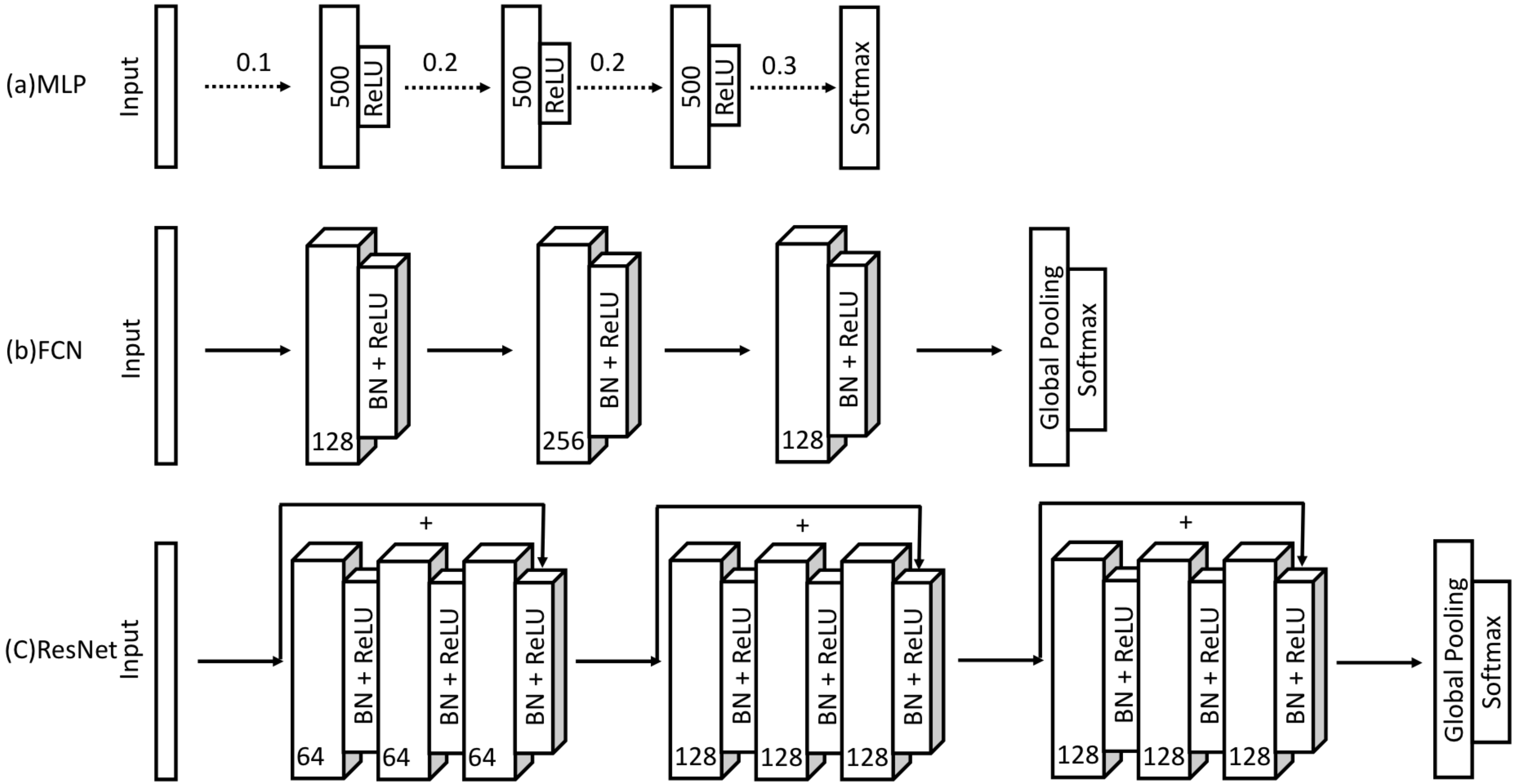


Fig. 1. The network structure of three tested neural networks. Dash line indicates the operation of dropout.

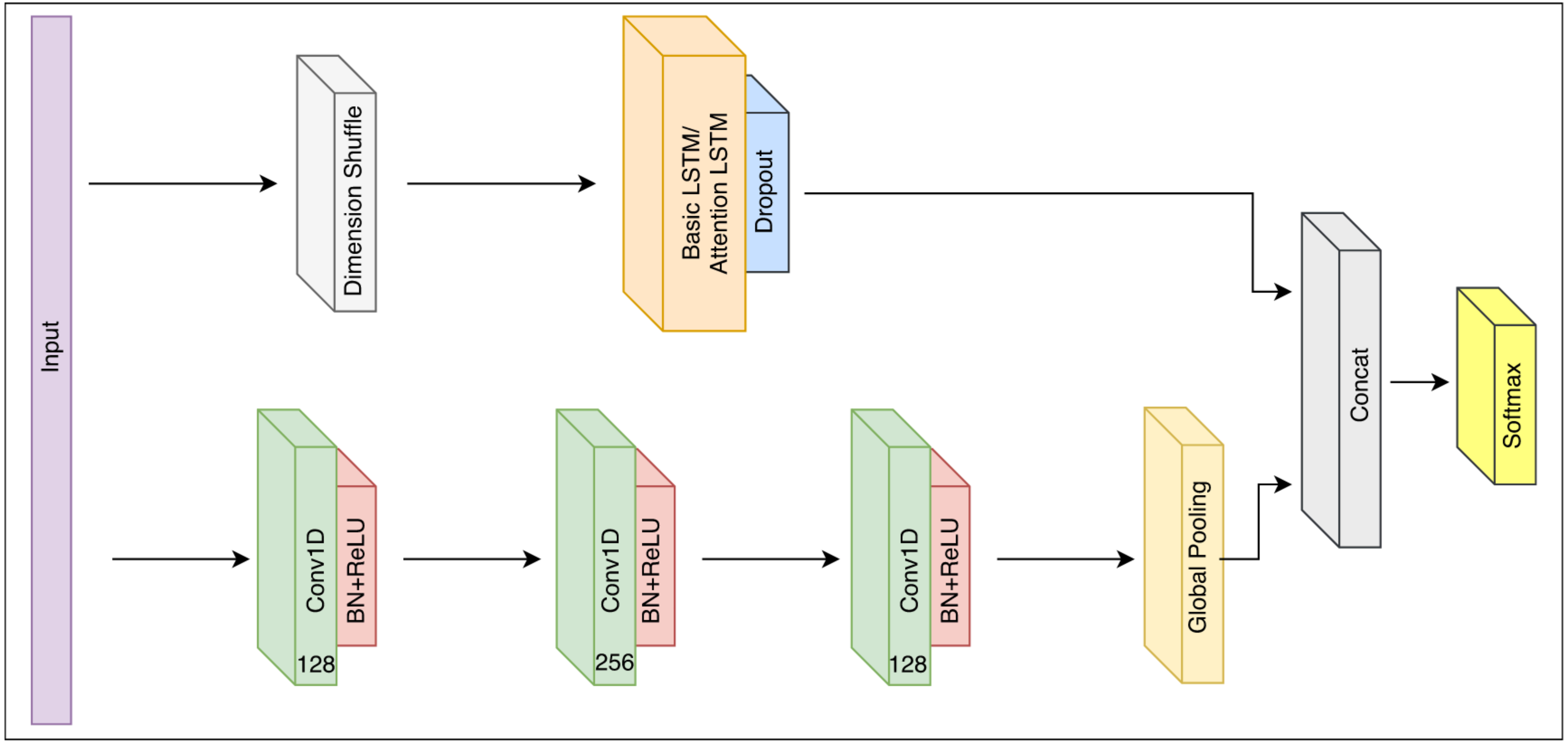
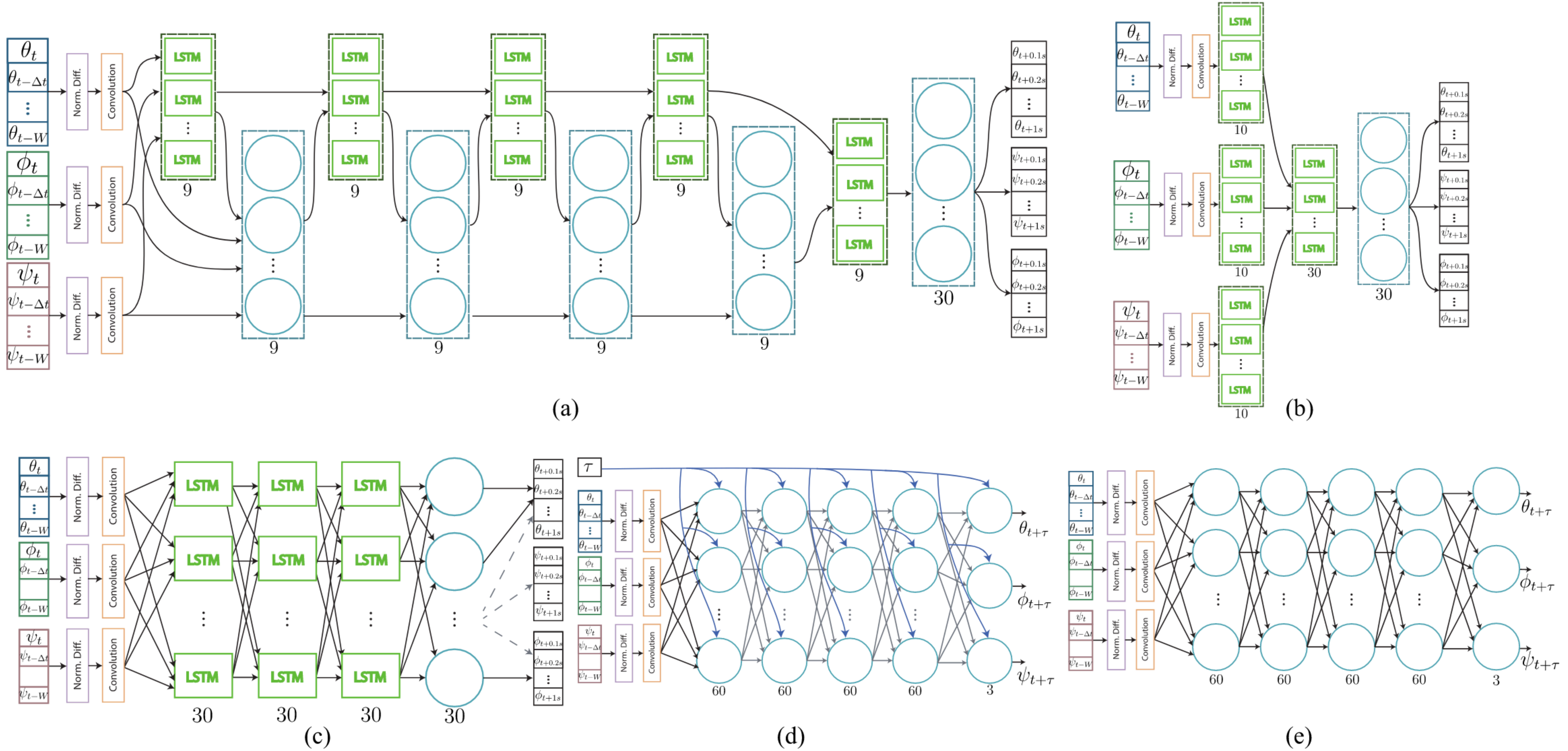


FIGURE 1. The LSTM-FCN architecture. LSTM cells can be replaced by Attention LSTM cells to construct the ALSTM-FCN architecture.



θ_t
$\theta_{t-\Delta t}$
θ_{t-W}
ϕ_t
$\phi_{t-\Delta t}$
ϕ_{t-W}
ψ_t
$\psi_{t-\Delta t}$
ψ_{t-W}
Norm. Diff.
Convolution
LSTM
9
30
10
60
3
$\theta_{t+0.1s}$
$\theta_{t+0.2s}$
θ_{t+1s}
$\psi_{t+0.1s}$
$\psi_{t+0.2s}$
ψ_{t+1s}
$\phi_{t+0.1s}$
$\phi_{t+0.2s}$
ϕ_{t+1s}
τ
$\theta_{t+\tau}$
$\phi_{t+\tau}$
$\psi_{t+\tau}$
(a)
(b)
(c)
(d)
(e)

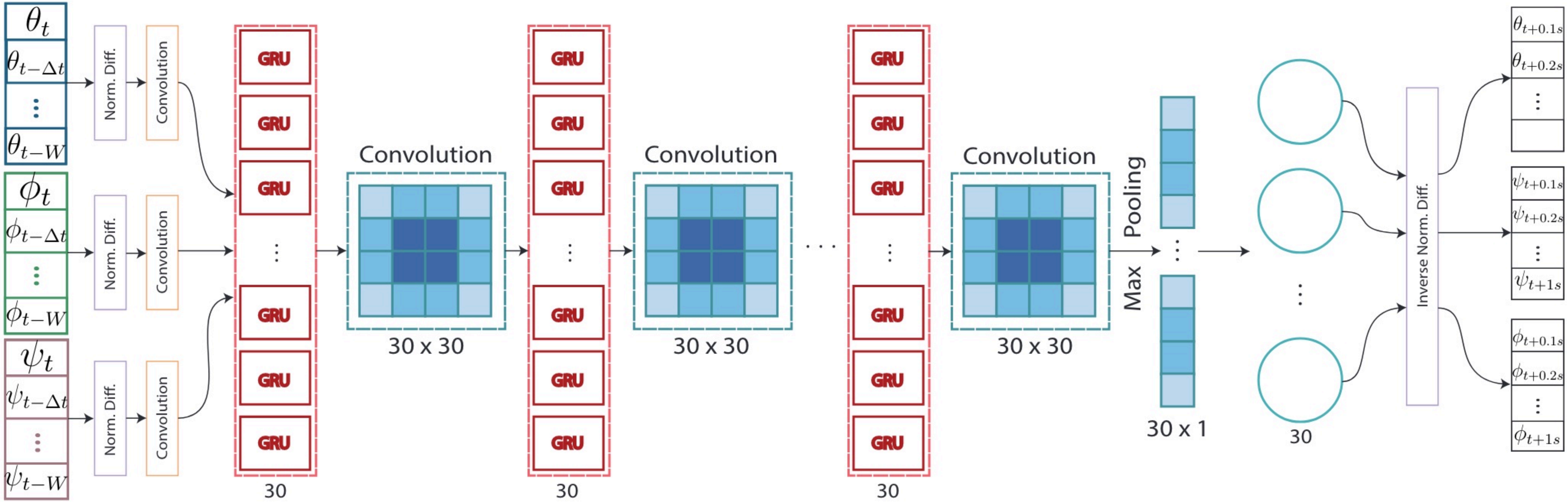


Fig. 9: Schematic overview of our proposed deep neural network for head-motion prediction. The input is first transformed to normalized difference to ensure generalization, and passed through a convolution unit that acts as a low-pass filter. Six sequential GRU and convolution units compute the most distinct features at different granularities. A subsequent max pooling layer downsamples the output of the last convolution layer und preserves the most significant features. After a dense feed-forward network, the differences are inverted to absolute values. The output predicts a whole sequence of future orientation values ($\vec{\xi}^{\text{pred}}_{t+n\cdot 100\text{ms}}\ \forall n \in \mathbb{Z}, n = 1, ..., 10$).

C. *Acceleration Integration*

The data collected by IMU includes acceleration and Euler angle. Generally speaking, displacement can be obtained by integrating acceleration twice. In addition to using model to predict displacement, We also tried to integrate the acceleration collected by IMU to get the velocity by Equation (2) where v_t is the velocity at time t; a_t is the acceleration at time t. The integration result of velocity is in Fig. 3. We can see the x-axis has an increasing positive deviation as time goes by; y-axis and z-axis also have small deviations respectively. Next, we used Equation (3) where d_t is the displacement at time t to integrate the velocity and get the displacement. The displacement of the target, prediction and integration compared result is in Fig. 4. Green line is integration result, as for blue and orange line are the target and prediction result respectively. We can see that integration result is much worse than prediction result of model. We speculate that it should be related to the errors of IMU. When testing IMU, we found that it still has a slight acceleration even if IMU is static. These errors would be accumulated and cause a large deviation in displacement when integration acceleration twice.

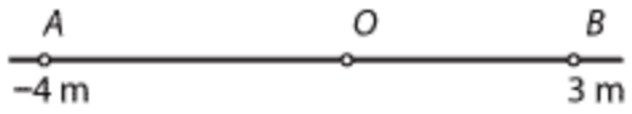
$$v_t = v_{t-1} + a_t * t \tag{2}$$

$$d_t = v * t + \frac{1}{2} * a_t * t^2 \tag{3}$$

Position

The line is coordinatised and referenced from a point O, the origin. For a horizontal line, the convention is that positions to the right of O are positive, and positions to the left are negative.

For example:



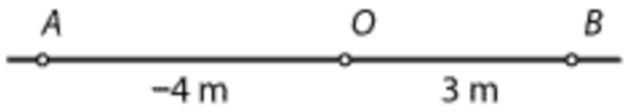
- The position of the particle at B is 3 m.
- The position of the particle at A is -4 m.

The position of a particle is often thought of as a function of time, and we write $x(t)$ for the position of the particle at time t.

Displacement

The **displacement** of a particle moving in a straight line is the change in its position. If the particle moves from the position $x(t_1)$ to the position $x(t_2)$, then its displacement is $x(t_2) - x(t_1)$ over the time interval $[t_1, t_2]$. In particular, the position of a particle is its displacement from the origin.

For example:



- If a particle moves from O to B, its displacement is 3 m.
- If a particle moves from O to A, its displacement is −4 m.
- If a particle moves from A to B, its displacement is 7 m.
- If a particle moves from B to A, its displacement is −7 m.

Position and displacement are vector quantities, that is, they have both magnitude and direction. In this module, we are dealing with vectors in one dimension. The sign of the quantity (positive or negative) indicates its direction. The absolute value of the quantity is its magnitude.