$$s_i(k+1) - s_i(k) = \begin{bmatrix} \overline{\theta}_{s_1} & \overline{\theta}_{s_2} & \overline{\theta}_{s_3} - \overline{\theta}_{v_1} & \overline{\theta}_{s_4} - \overline{\theta}_{v_2} & \overline{\theta}_{v_4} & \overline{\theta}_{v_3} \end{bmatrix} \begin{bmatrix} s_i(k-1) \\ s_i(k-2) \\ v_i(k) \\ v_i(k-1) \\ v_i(k+1) \\ -v_i(k-2) \end{bmatrix} \tag{1}$$

$$\begin{gathered} Given\ Variables: \\ \overline{\theta}_{s_1} \\ \overline{\theta}_{s_2} \\ \overline{\overline{\theta}_{s_3}} \\ \overline{\overline{\theta}_{s_4}} \\ \overline{\theta}_{v_4} \\ \overline{\theta}_{v_3} \end{gathered} \tag{2}$$

$$\begin{gathered} To\ be\ solved: \\ \theta_{s_1} \\ \theta_{s_2} \\ \theta_{s_3} \\ \theta_{s_4} \\ \theta_{s_5} \\ \theta_{v_1} \\ \theta_{v_2} \\ \theta_{v_3} \\ \theta_{v_4} \end{gathered} \tag{3}$$

$$s_i(k+1) - s_i(k) = \begin{bmatrix} \overline{\theta}_{s_1} & \overline{\theta}_{s_2} & \overline{\theta}_{s_3} - \overline{\theta}_{v_1} & \overline{\theta}_{s_4} - \overline{\theta}_{v_2} & \overline{\theta}_{v_4} & \overline{\theta}_{v_3} \end{bmatrix} \begin{bmatrix} s_i(k-1) \\ s_i(k-2) \\ v_i(k) \\ v_i(k-1) \\ v_i(k+1) \\ -v_i(k-2) \end{bmatrix} \tag{4}$$

$$
\begin{aligned}
&Definitions:\\
\overline{\theta}_{s_1} &= \theta_{s_1}\\
\overline{\theta}_{s_2} &= \theta_{s_2}\\
\overline{\theta}_{s_3} &= \theta_{s_3}\\
\overline{\theta}_{s_4} &= \theta_{s_4}\\
\overline{\theta}_{v_1} &= \frac{\theta_{v_1}\theta_{s_5}}{\theta_{v_4}}\\
\overline{\theta}_{v_2} &= \frac{\theta_{v_2}\theta_{s_5}}{\theta_{v_4}}\\
\overline{\theta}_{v_3} &= \frac{\theta_{v_3}\theta_{s_5}}{\theta_{v_4}}\\
\overline{\theta}_{v_4} &= \frac{\theta_{s_5}}{\theta_{s_4}}\\
\overline{\overline{\theta}_{s_3}} &= \overline{\theta}_{s_3} - \overline{\theta}_{v_1}\\
\overline{\overline{\theta}_{s_4}} &= \overline{\theta}_{s_4} - \overline{\theta}_{v_2}
\end{aligned}
\tag{5}
$$

$$
s_i(k+1) - s_i(k) = \begin{bmatrix} \overline{\theta}_{s_1} & \overline{\theta}_{s_2} & \overline{\overline{\theta}}_{s_3} & \overline{\overline{\theta}}_{s_4} & \overline{\theta}_{v_4} & \overline{\theta}_{v_3} \end{bmatrix} \begin{bmatrix} s_i(k-1) \\ s_i(k-2) \\ v_i(k) \\ v_i(k-1) \\ v_i(k+1) \\ -v_i(k-2) \end{bmatrix} \tag{6}
$$

$$
\begin{aligned}
&Definitions: \\
\overline{\theta}_{s_1} &= \theta_{s_1} \\
\overline{\theta}_{s_2} &= \theta_{s_2} \\
\overline{\theta}_{v_3} &= \frac{\theta_{v_3}\theta_{s_5}}{\theta_{v_4}} \\
\overline{\theta}_{v_4} &= \frac{\theta_{s_5}}{\theta_{s_4}} \\
\overline{\overline{\theta}}_{s_4} &= \theta_{s_4} - \frac{\theta_{v_2}\theta_{s_5}}{\theta_{v_4}} \\
\overline{\overline{\theta}}_{s_3} &= \theta_{s_3} - \frac{\theta_{v_1}\theta_{s_5}}{\theta_{v_4}}
\end{aligned} \tag{7}
$$

Normalisation step

$$
s_i(k+1) - s_i(k) = \begin{bmatrix} \theta_{s_1} & \theta_{s_2} & \theta_{s_3} - \frac{\theta_{v_1}\theta_{s_5}}{\theta_{v_4}} & \theta_{s_4} - \frac{\theta_{v_2}\theta_{s_5}}{\theta_{v_4}} & \frac{\theta_{s_5}}{\theta_{s_4}} & \frac{\theta_{v_3}\theta_{s_5}}{\theta_{v_4}} \end{bmatrix} \begin{bmatrix} s_i(k-1) \\ s_i(k-2) \\ v_i(k) \\ v_i(k-1) \\ v_i(k+1) \\ -v_i(k-2) \end{bmatrix} \tag{8}
$$

$$
||t - Ax||^2 \tag{9}
$$

$$
||t - Ax||^2 + lambda||x||^2 \tag{10}
$$

$$
\| \begin{bmatrix} t & 0 \end{bmatrix} - diag(A, I * \sqrt{\lambda})x\|^2 \tag{11}
$$

$$
s_i(k+1) - s_i(k) = \begin{bmatrix} s_i(k-1) & s_i(k-2) & v_i(k) & v_i(k-1) & v_i(k+1) & v_i(k) & v_i(k-1) & -v_i(k-2) \end{bmatrix} \tag{12}
$$

tsdkflsdjf
sldk

sdf
sdf

Distance:

$$\begin{aligned} s_i(k+1) &= s_i(k) + \theta_{s_1} s_i(k-1) + \theta_{s_2} s_i(k-2) + \theta_{s_3} v_i(k) + \theta_{s_4} v_i(k-1) + \theta_{s_5} a_i(k) \\ a_i(k) &= \frac{s_i(k+1) - s_i(k) - \theta_{s_1} s_i(k-1) - \theta_{s_2} s_i(k-2) - \theta_{s_3} v_i(k) - \theta_{s_4} v_i(k-1)}{\theta_{s_5}} \end{aligned} \tag{13}$$

Velocity:

$$\begin{aligned} v_i(k+1) &= \theta_{v_1} v_i(k) + \theta_{v_2} v_i(k-1) + \theta_{v_3} v_i(k-2) + \theta_{v_4} a_i(k) \\ a_i(k) &= \frac{v_i(k+1) - \theta_{v_1} v_i(k) - \theta_{v_2} v_i(k-1) - \theta_{v_3} v_i(k-2)}{\theta_{v_4}} \end{aligned} \tag{14}$$

Equate by acceleration $a_i(k)$:

$$\theta_{v_4}\Big(s_i(k+1) - s_i(k) - \theta_{s_1} s_i(k-1) - \theta_{s_2} s_i(k-2) - \theta_{s_3} v_i(k) - \theta_{s_4} v_i(k-1)\Big) = \theta_{s_5}\Big(v_i(k+1) - \theta_{v_1} v_i(k) - \theta_{v_2} v_i(k-1) - \theta_{v_3} v_i(k-2)\Big) \tag{15}$$

Solve for $s_i(k+1) - s_i(k)$:

$$\theta_{v_4} s_i(k+1) - \theta_{v_4} s_i(k) = \theta_{v_4}\theta_{s_1} s_i(k-1) + \theta_{v_4}\theta_{s_2} s_i(k-2) + \theta_{v_4}\theta_{s_3} v_i(k) + \theta_{v_4}\theta_{s_4} v_i(k-1) \tag{16}$$

$$+ \theta_{s_5} v_i(k+1) - \theta_{s_5}\theta_{v_1} v_i(k) - \theta_{s_5}\theta_{v_2} v_i(k-1) - \theta_{s_5}\theta_{v_3} v_i(k-2) \tag{17}$$

$$\begin{aligned} s_i(k+1) - s_i(k) = {} & \theta_{s_1} s_i(k-1) + \theta_{s_2} s_i(k-2) + \theta_{s_3} v_i(k) + \theta_{s_4} v_i(k-1) \\ & + \frac{\theta_{s_5}}{\theta_{v_4}} v_i(k+1) - \frac{\theta_{s_5}\theta_{v_1}}{\theta_{v_4}} v_i(k) - \frac{\theta_{s_5}\theta_{v_2}}{\theta_{v_4}} v_i(k-1) - \frac{\theta_{s_5}\theta_{v_3}}{\theta_{v_4}} v_i(k-2) \end{aligned}$$

Solve system:

$$s_i(k+1) - s_i(k) = \begin{bmatrix} s_i(k-1) & s_i(k-2) & v_i(k) & v_i(k-1) & v_i(k+1) & v_i(k) & v_i(k-1) & v_i(k-2) \end{bmatrix} \begin{bmatrix} \theta_{s_1} \\ \theta_{s_2} \\ \theta_{s_3} \\ \theta_{s_4} \\ \frac{\theta_{s_5}}{\theta_{v_4}} \\ \frac{\theta_{s_5}\theta_{v_1}}{\theta_{v_4}} \\ \frac{\theta_{s_5}\theta_{v_2}}{\theta_{v_4}} \\ \frac{\theta_{s_5}\theta_{v_3}}{\theta_{v_4}} \end{bmatrix} \tag{18}$$

To solve this we use:

$$||t - Ax||^2 \tag{19}$$

Where:

$$t = s_i(k+1) - s_i(k) \tag{20}$$

$$A = \begin{bmatrix} s_i(k-1) & s_i(k-2) & v_i(k) & v_i(k-1) & v_i(k+1) & v_i(k) & v_i(k-1) & v_i(k-2) \end{bmatrix} \tag{21}$$

$$x = \begin{bmatrix} \theta_{s_1} \\ \theta_{s_2} \\ \theta_{s_3} \\ \theta_{s_4} \\ \frac{\theta_{s_5}}{\theta_{v_4}} \\ \frac{\theta_{s_5}\theta_{v_1}}{\theta_{v_4}} \\ \frac{\theta_{s_5}\theta_{v_2}}{\theta_{v_4}} \\ \frac{\theta_{s_5}\theta_{v_3}}{\theta_{v_4}} \end{bmatrix} \tag{22}$$

To solve for 9 parameters in x, we normalize the system:

$$\left\| \begin{bmatrix} t \\ 0 \end{bmatrix} - \begin{bmatrix} A & 0 \\ 0 & \mathbb{I} * \sqrt{\lambda} \end{bmatrix} \begin{bmatrix} x \\ x" \end{bmatrix} \right\|^2 \tag{23}$$

New equation:
We want to sovle this system

$$a(k-1) = -c_1 a(k) + c_2(v(k-1) - v(k)) \tag{24}$$

$$a(k-1) = -c_3 a(k) + c_4(s(k+1) - s(k) - v(k)) \tag{25}$$