We need to solve for the sensitivity matrix $\frac{\partial z}{\partial q}$.

$$\begin{aligned} \dot{z} &= f(z(t); q) \\ z(0) &= z_0 \end{aligned}$$

Differentiating with respect to q and passing the time derivative through yields

$$\left(\frac{\dot{\partial z}}{\partial q}\right)(t) = \frac{\partial f}{\partial z}(z(t, q_0); q_0) \cdot \frac{\partial z}{\partial q} + \frac{\partial f}{\partial q}(z(t, q_0); q_0).$$

This can be written as an $n \times m$ matrix system of ODEs for the sensitivity matrix $r(t) = \frac{\partial z}{\partial q}$

$$\begin{aligned} \dot{r}(t) &= A_0(t)\, r(t) + g_0(t) \\ r(0) &= 0. \end{aligned}$$

This yields the local system sensitivity about the point $q_0 \in \Re^m$.

Model

$$
\begin{aligned}
\dot{X} &= \lambda - d\,X - \beta\,[1 - f\,u(t)]\,XV \\
\dot{Y} &= \beta\,[1 - f\,u(t)]\,XV - a\,Y - p\,YZ \\
\dot{W} &= c\,XYW - cq\,YW - bW \\
\dot{Z} &= cq\,YW - h\,Z \\
\dot{V} &= k\,Y - \mu\,V
\end{aligned}
$$

Compartments

$$
\begin{aligned}
X &= \text{Uninfected T helper cells} \\
Y &= \text{Infected T helper cells} \\
W &= \text{Immune Precursor Cytotoxic T Lymphocyte} \\
Z &= \text{Immune Effector Cytotoxic T Lymphocyte} \\
V &= \text{Free Virus}
\end{aligned}
$$

Parameters

parameter	definition
λ	target cell source
d	net natural growth/death of target cells
β	infectivity of cells, due to XV
f	treatment efficacy factor ($0 \leq f \leq 1$)
a	net natural growth/death of infected cells
p	death rate of infected cells due to immune response (YZ)
c	growth of CTL precurors out of XYW
b	natural death of CTL precursors
$c\,q$	CTLe growth due to infected cells/CTLp (YW)
h	natural death of CTL effectors
k	growth rate of virions due to infected cells
μ	net natural growth/death of virions