Quasi-Newton Issues
Large Scale Systems

- B_k has $\approx n^2/2$ elements
- Each rank-two update requires $2n$ elements

- **Use an iterative solver for**

$$B_k p_k = -g_k$$

For example, write B as a sum of its diagonal (D) plus the off-diagonal part (O) and we have

$$Bp = -g \longrightarrow Dp^{n+1} = -(Op^n + g)$$

- **Alternatively we could update the *inverse* Hessian**
- **We store only several (say 10)**

of the last updates

$$
\begin{aligned}
\boldsymbol{B_k = B_0} &+ \boldsymbol{u_k u_k^T + v_k v_k^T} \\
&+ \boldsymbol{u_{k-1} u_{k-1}^T + v_{k-1} v_{k-1}^T} \\
&\vdots \\
&+ \boldsymbol{u_{k-9} u_{k-9}^T + v_{k-9} v_{k-9}^T}
\end{aligned}
$$

Conjugate Gradient Method

- Only requires storing a few vectors of length n
- Finite termination on quadratics (pos. def.)
- Need accurate 1-D searches

- **R. Fletcher and C. Reeves, Function minimization by conjugate gradients, *Computer Journal*, 7, 1964, 163-168.**
- **M. Hestenes and E. Steifel, Methods of conjugate gradients for solving linear systems, J. Res. N. B. S., 49, 1952, 409-436.**