IDENTIFYING QUANTITATIVE TRAIT LOCI USING SENSITIVITY ANALYSIS

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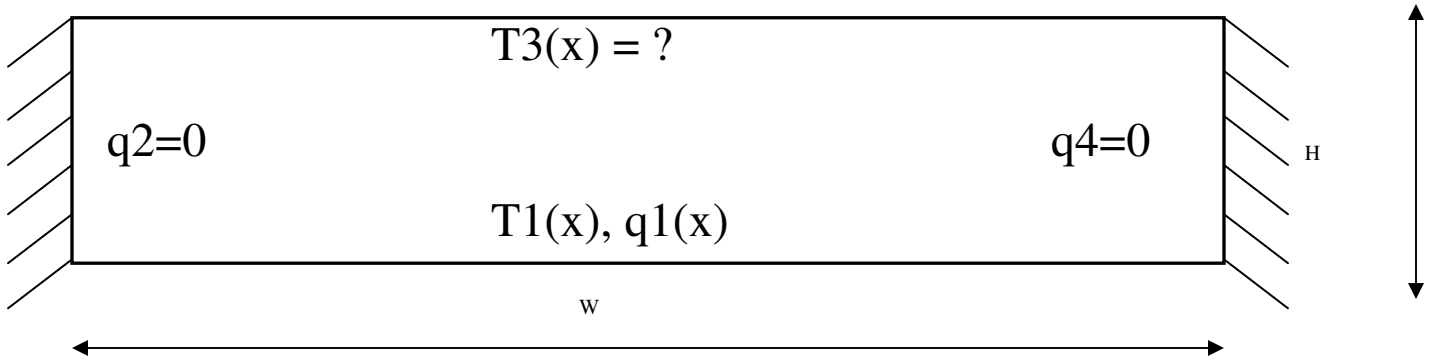
Inverse Problem



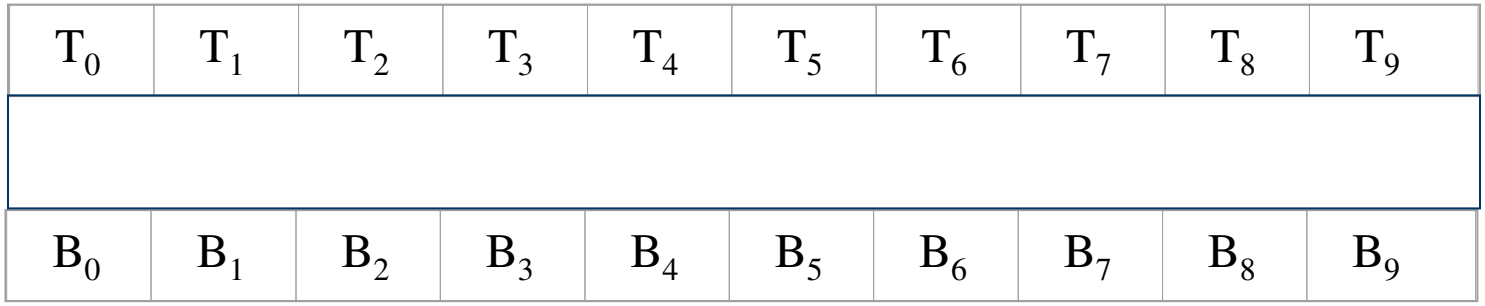
Low aspect ratio (H/W = 0.1) enclosure has been used.

Governing Equation of Radiative Heat Transfer

$$\frac{q(\mathbf{r})}{\varepsilon} - \int_A \left(\frac{1}{\varepsilon} - 1\right) q(\mathbf{r}')\, dF_{dA-dA'} = E_b(\mathbf{r}) - \int_A E_b(\mathbf{r}')\, dF_{dA-dA'}$$

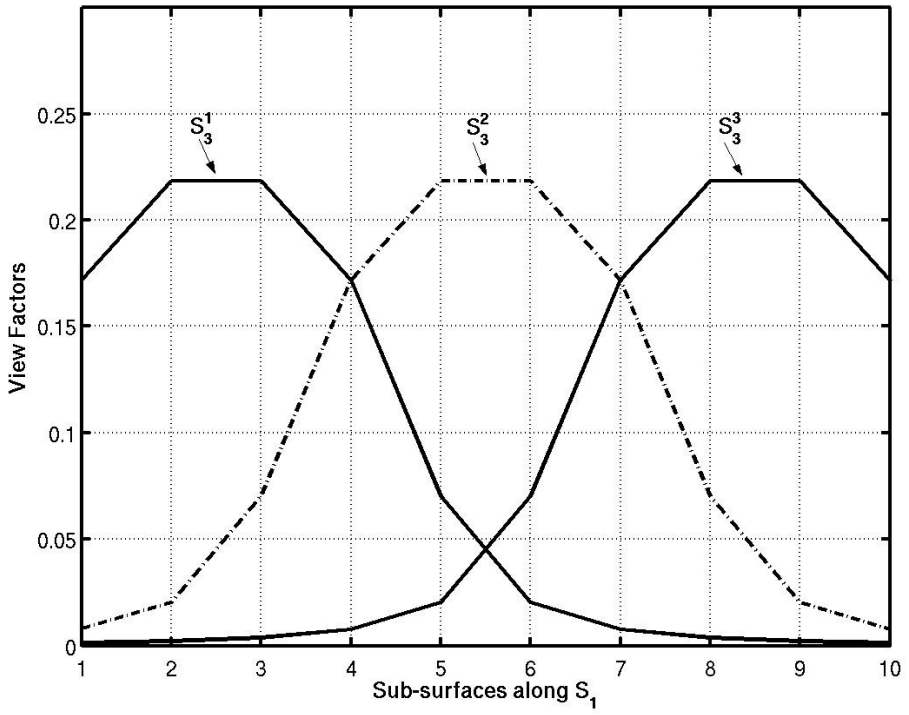
- In the absence of participating medium
- No external irradiation
- Fredholm integral equation of 2nd kind if
  - Emissive powers/temperatures are known
  - Heat flux to be calculated

View Factors



- Function of distance and geometry between any two elements and determine the amount of energy transfer between the surfaces.
- Remain the same irrespective of boundary conditions

Variation of View Factors

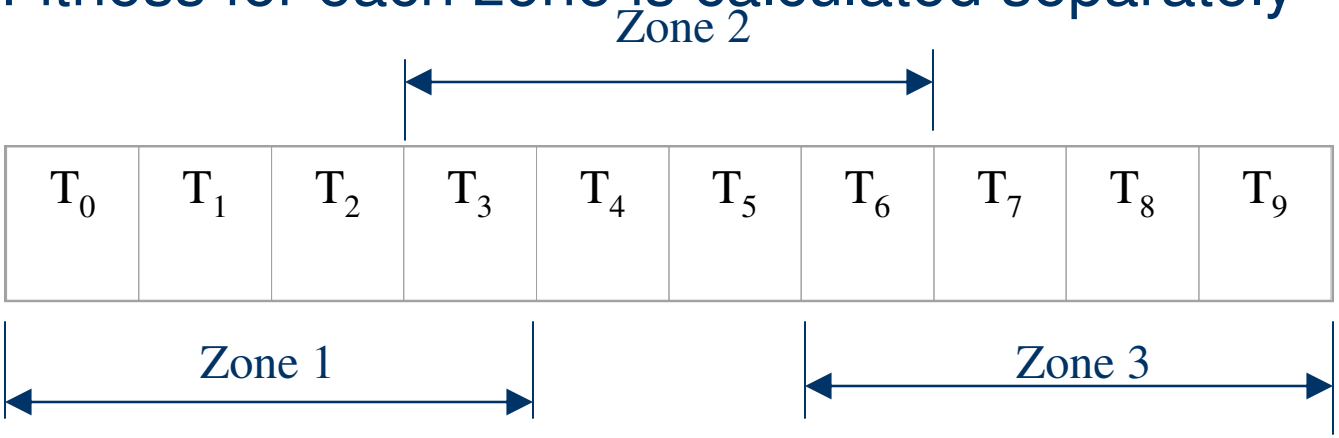


Quantitative Trait Loci

- Concept from genetics
- Genetic map on a chromosome that is associated with a specific trait of the creature
- The quantitative trait is the required temperature profile
- Chromosomes have been evolved in blocks that do not have much dependence on each other
- Dependence between the blocks is determined from view factors

Chromosome Division

- QTL's are used to combine portions of two chromosomes
- String of length 10
- Divided into 3 overlapping zones
- Fitness for each zone is calculated separately



Fitness Functions

$$(SSE)_j = \sum_{i=1}^{N_z} (q_{1i}(x) - q_{1i}^{*}(x))^2$$

- Sum of Squared Error (SSE) – flux due to candidate solution and required heat flux
- 1st order Tikhonov regularization

Fitness Functions

- For each chromosome 3 fitness functions are evaluated, based on how closely the temperatures in these zones match the required heat fluxes *f1, f2, f3*
- Each of these are minimized

Crossover Operator

- Parent is compared with co-parent in each of the three zones (based on fitness functions)
- Crossover sites are restricted to the beginning and end of the zones

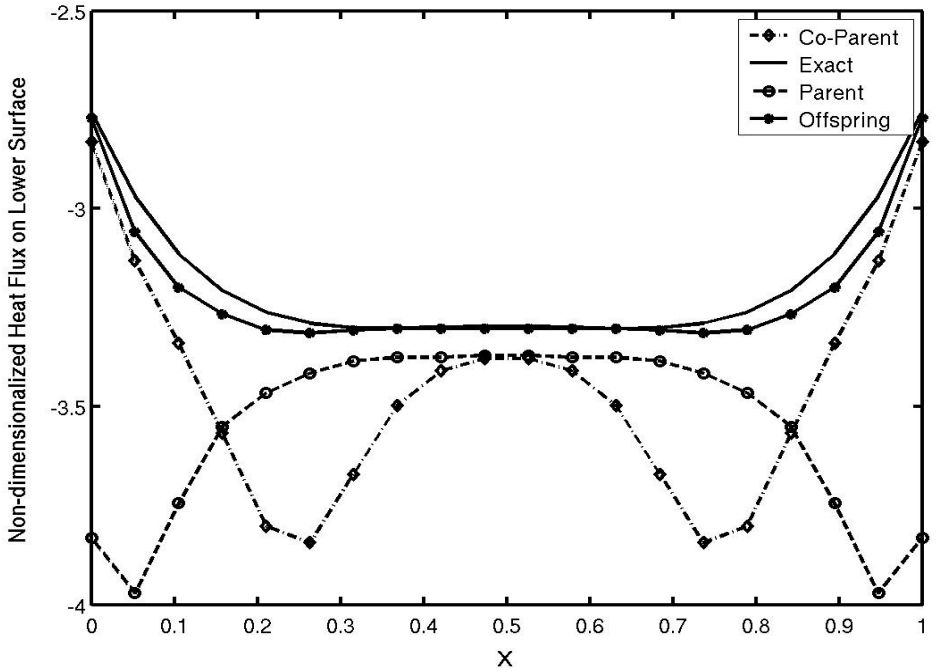
Crossover Operator

- In each zone the parent is either better (B) or worse (W) than the co-parent
- Eight cases of comparisons

Case	f_1	f_2	f_3
1	B	B	B
2	B	B	W
3	B	W	W
4	W	W	W
5	W	W	B
6	W	B	B
7	W	B	W
8	B	W	B

Comparison of Heat fluxes

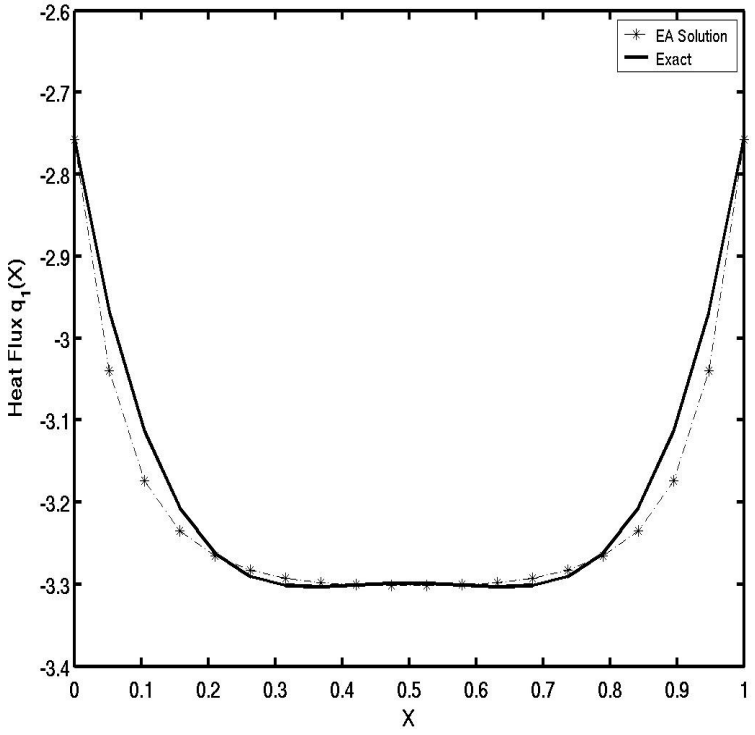
- Comparison of heat fluxes generated by parent, co-parent and off spring



- The parent and co-parent would not have been awarded very high fitness values based on a single fitness evaluation
- Performing a planned crossover based on multiple fitness values, a better result is obtained

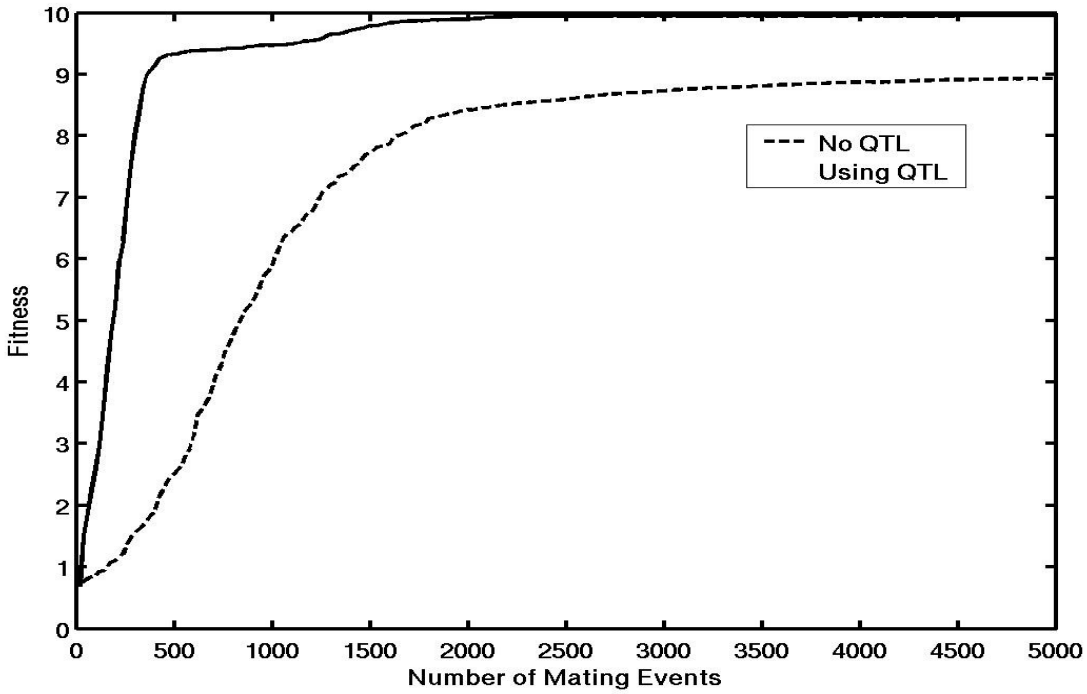
Results

- Heat Flux from EA runs



Comparison of fitness values

- Significant increase in fitness

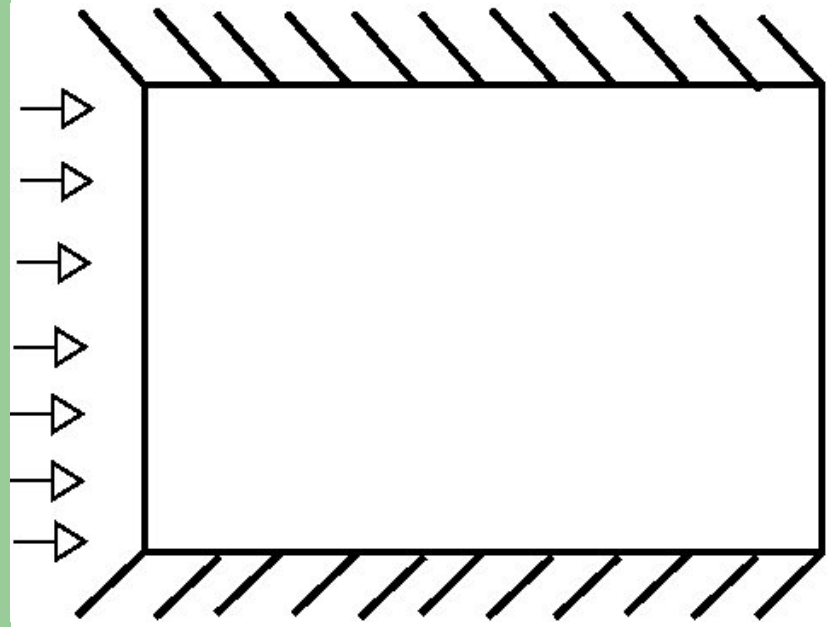


QTL

- Divide an optimization problem into smaller problems
- Makes the search process easier

- A single fitness was calculated for the whole string (QTL case)
- EA finds it easier to resolve stings of shorter length

Extending the Concept to Conduction Problems

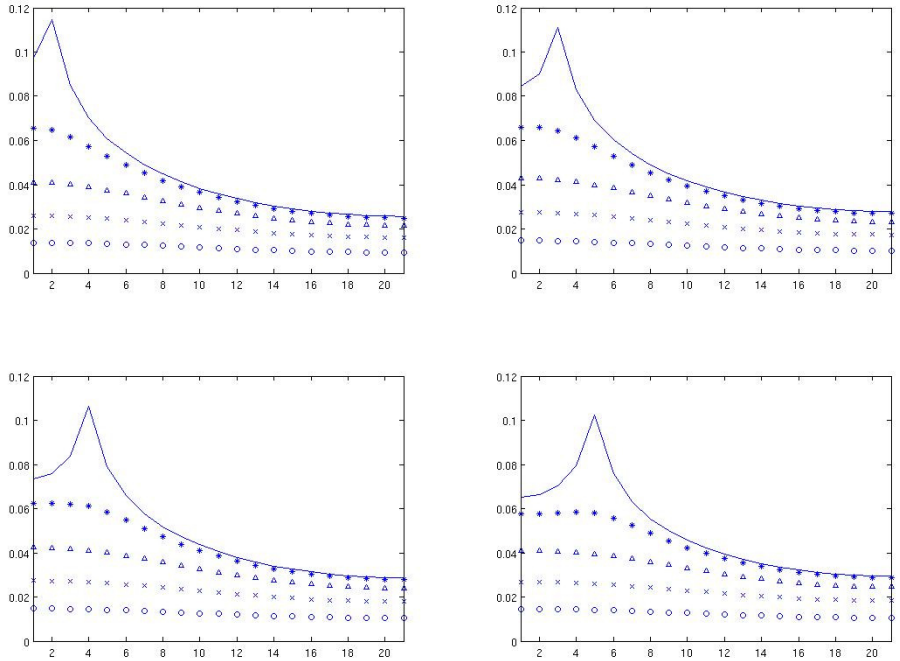


- Linear heat conduction problem
- Identify QTL's

Sensitivity Coefficients

- Compute $\frac{\partial T}{\partial q}$ at grid points
- Changed heat flux value at grid point
  - computed new temperature distribution

Sensitivity Coefficients



Conclusions

- Multiple fitness evaluations for a single chromosome increases the speed of convergence to solution
- This method can be used in problems where the domain knowledge of the problem can be used to identify QTL's
- To solve inverse problem on the 2-D conduction case discussed