PROGRAM A

FIRE SPREAD SIMULATION
PROJECT A5

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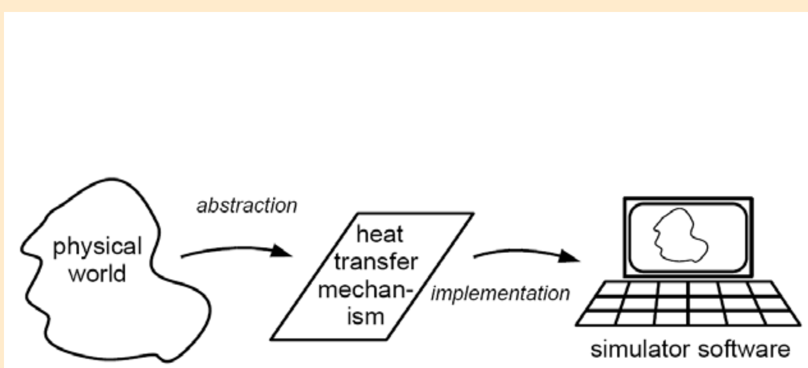
PROGRAM A : Fire Spread Simulation Project A 5



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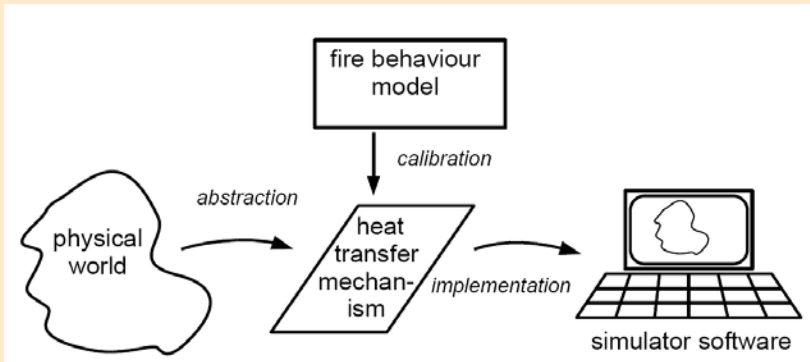
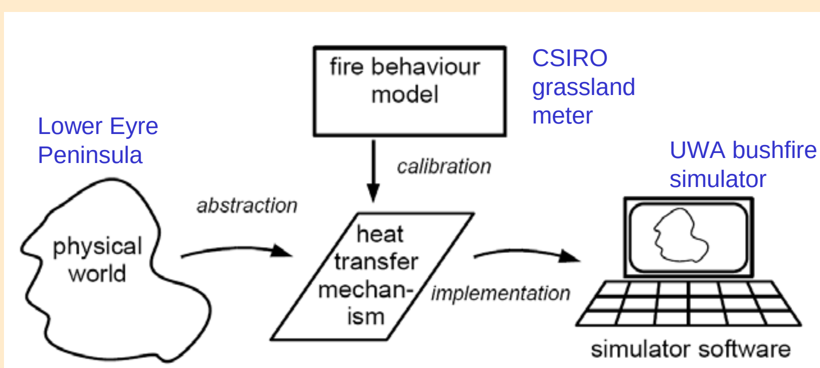

fire behaviour model
calibration
abstraction
physical world
heat transfer mechan-ism
implementation
simulator software


fire behaviour model
CSIRO grassland meter
Lower Eyre Peninsula
UWA bushfire simulator
calibration
abstraction
physical world
heat transfer mechan-ism
implementation
simulator software

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Research Challenge:

- "better" simulations: more physically realistic
- "faster" simulations : complete simulation runs in a few minutes
- trade off: accuracy versus performance
- all simulations are abstractions / approximations of real world

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Relationship to Existing Simulation Technology

Farsite (US Forest Service, Missoula)/ Prometheus (Alberta, Canada)

- Uses Huygens' Principle
- Each point on the fire front behaves independently
- Non-extensible, i.e. cannot capture fire-atmosphere interaction
- UWA bushfire simulator more realistic

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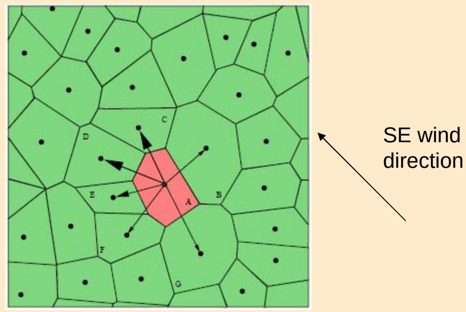
Relationship to Existing Simulation Technology

Firetec (Los Alamos, USA) / Clark & Coen (UBC and Boulder)

- Based on underlying physics
- Computationally intensive
- Long simulation times (hours)
- UWA bushfire simulator faster (minutes)

UWA Bushfire Simulator: approach taken.

- use an underlying heat transfer mechanism
- generate, transport and consume heat quanta
- based on 2nd Law of Thermodynamics
- occurrence of *discrete* heat transfer events
- occur between *discrete* landscape patches



- burning patches *generate* heat
- unburned neighbours *consume* heat
- heat *transferred* from hot to cold (2^{nd} Law)

Why this Approach?

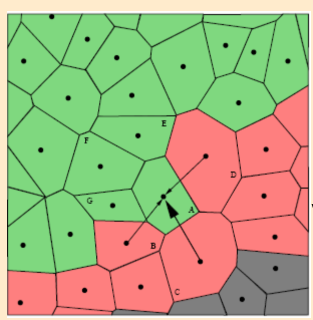
- mechanism underpinned by physics of thermodynamics
- builds on our mathematical modelling and simulation skills and experience in *interacting concurrent systems*
- computational efficiency via *discrete event simulation*

Our approach:

- allows for future development of tractable mechanism for fire/atmosphere interaction
- adds to the science of fire spread simulation by developing a novel technique
- Capable of being tuned to include current or future fire behaviour models

Discrete Space

- discretise landscape into approx equal sized polygon patches
- avoids regular grid problems found in cellular automata



SE wind direction

- patches have neighbours - share common boundaries
- collection of patches form an interacting *system*
- system exhibits dynamic behaviour
- patches burn, generate heat, and interact to communicate heat between, as in a real bushfire

Fire Perimeter

- fire boundary easily determined from interface of burning and unburned patches
- fire spread is a consequence of our heat transfer mechanism
- existing fire behaviour models embedded in our heat transfer mechanism, for each fuel type
- achieved by setting parameters to match RoS of fire behaviour models

Discrete Events

- each patch has data capturing its *state*
- fuel type, fuel load, fuel moisture, location co-ordinates, slope
- patch ignites when received heat brings it up to ignition threshold

- burning patch distributes heat to cooler neighbours
- rate of heat transfer depends on state parameters including wind and slope
- heat transfer simulated by *sequence* of discrete heat transfer *events*
- each event transfers a discrete quantity of heat

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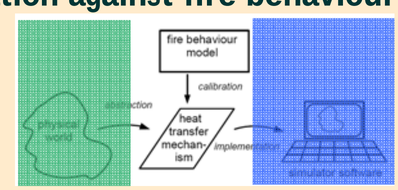
Calibration against fire behaviour models



Fire rate of spread

In the physical world depends on

- fuel type
- wind speed
- slope
- fuel moisture
- fuel load

In the simulation depends on

- heat production rate
- patch-patch transfer
- patch heat capacity

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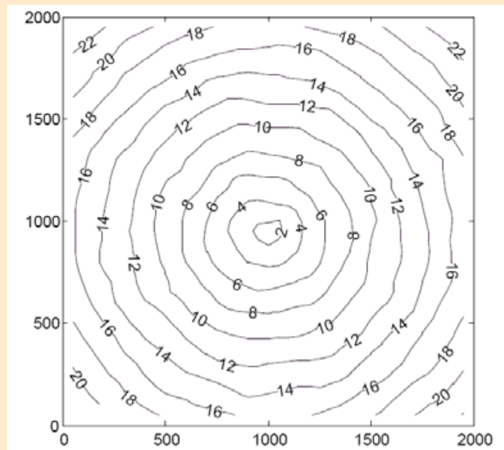
Initial results: point fire, no wind, homogeneous grass fuel

- distance (m) vs time (hours)
- ROS ≈ 55 m/h
- circular fire shape



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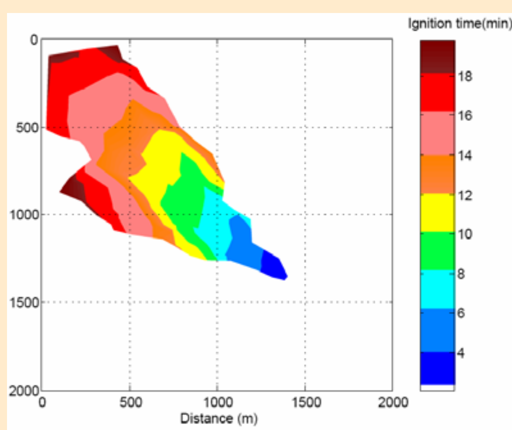
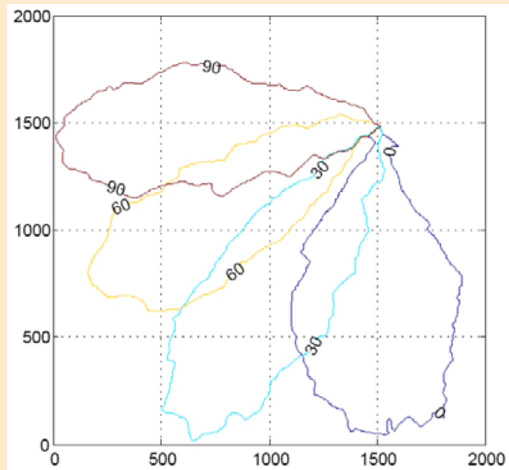
Initial results: point fire 30 km/h SE wind

- fire spreads in a NW direction
- acceleration from initial slow rate of spread (compare 1st 6 minutes with 3rd 6 minutes)



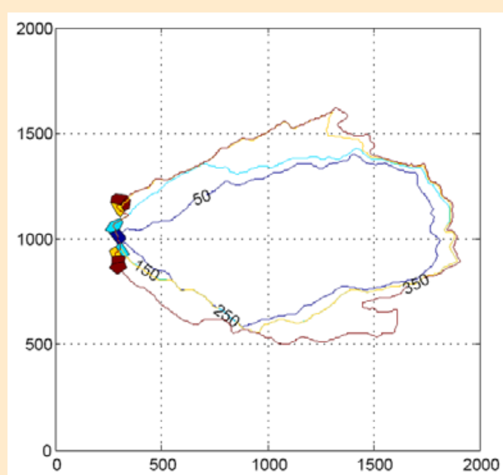
Fire spread for different wind directions

Because the grid is unstructured, there are no “preferred directions” for fire spread.



Initial results: Fire ignition width

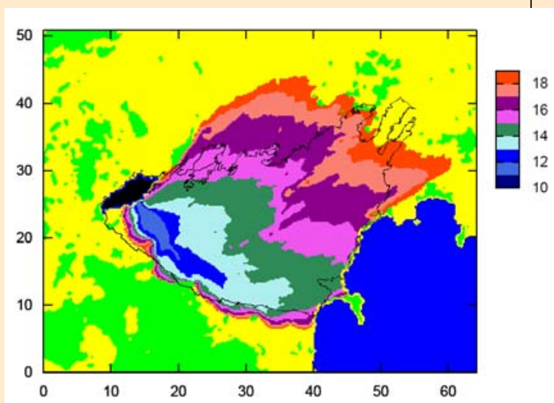
- Fire position after 15 minutes for different width ignition patterns
- Point fire initially travels more slowly than a line fire
- Caused by loss of some heat to lateral neighbours



Wangary SA, Jan 11, 2005 grass fire

- Fire spread SE from overnight position
- 2 wind changes: NW then W, then SW
- 2 fuel types, grass and forest
- Final fire perimeter in black

Distances in km, Time of day (hours)



Currently:

- heat transfer mechanism developed
- prototype simulator software developed
- CSIRO grassland model embedded into simulator
- experimentation with homogeneous fuel and varying wind strength
- Wangary, SA (January 05) fire simulation

Future:

- validate simulator against (high quality) experimental burn data (e.g. Project Vesta)
- simulation of Pickering Brook, Perth Hills
- more complex fuel and topography
- user interface development
- fire/atmosphere interaction mechanism development
- software development (beta version)

Landscape and Atmosphere Layer Interaction