GMIN 317 – Moteur de Jeux

Intelligence artificielle pour le jeu vidéo

Rémi Ronfard

Remi.ronfard@inria.fr

https://team.inria.fr/imagine/remi-ronfard/

Cette présentation va s'intéresser aux différentes techniques d'intelligence artificielle utilisées dans les moteurs de jeu.

Surtout sur le plan des méthodes génériques d'utilisation courante.

Ce cours est largement inspiré des cours de Marc Moulis et Benoit Lange.

Personnages non-joueurs (non-player characters)

- Comportements d'un personnage non joueur
  - Attaque, fuite, poursuite, patrouille
  - Recherche de chemins
  - Imitation/adaptation
  - Expression de sentiments
  - Apprentissage
  - Interaction avec les autres personnages
- Tous contrôlés par intelligence artificielle
- A chaque boucle du jeu (très vite)

Plan du cours

Recherche de chemins

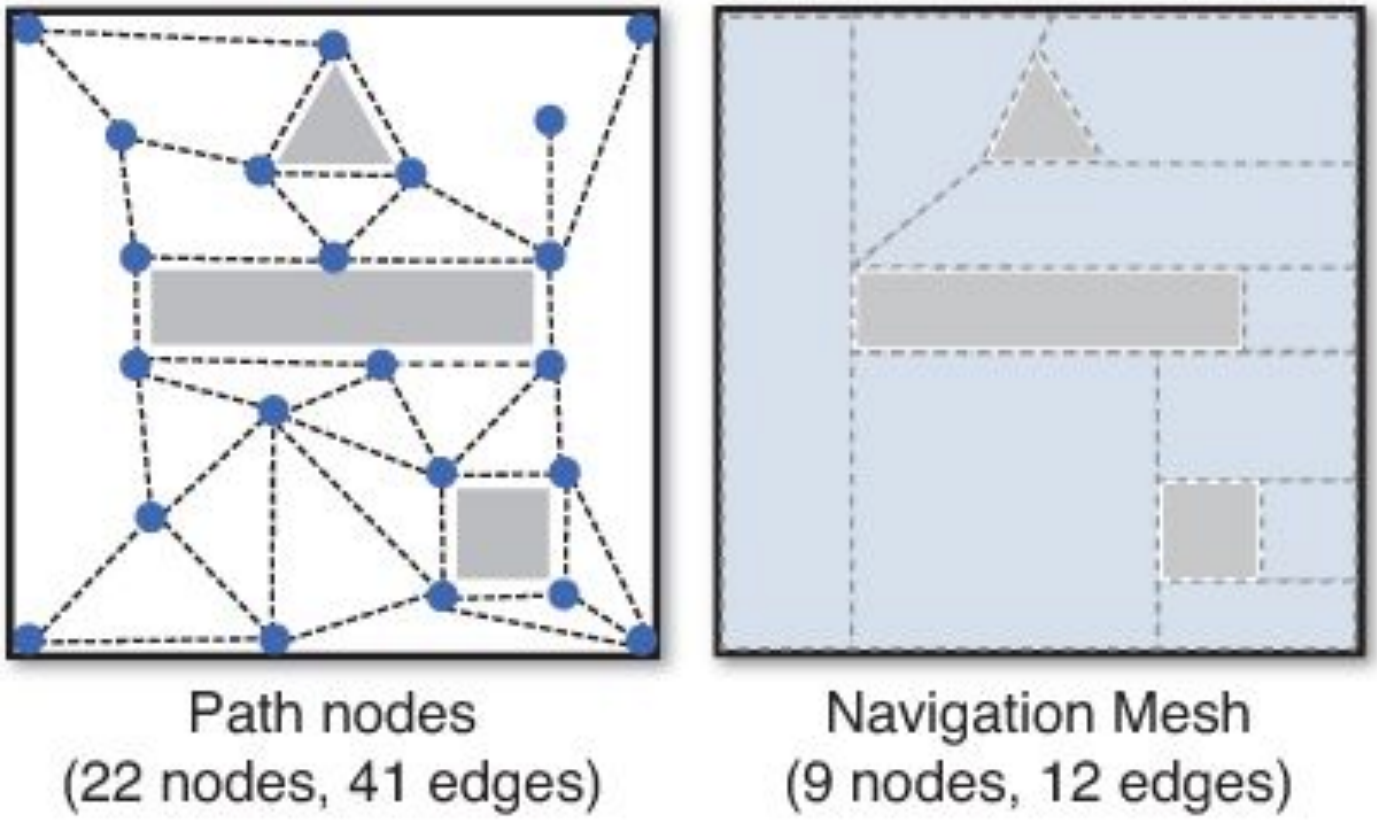
Machines d'états finis

Arbres de comportements

Caméras intelligentes

Intelligence artificielle des SIMS

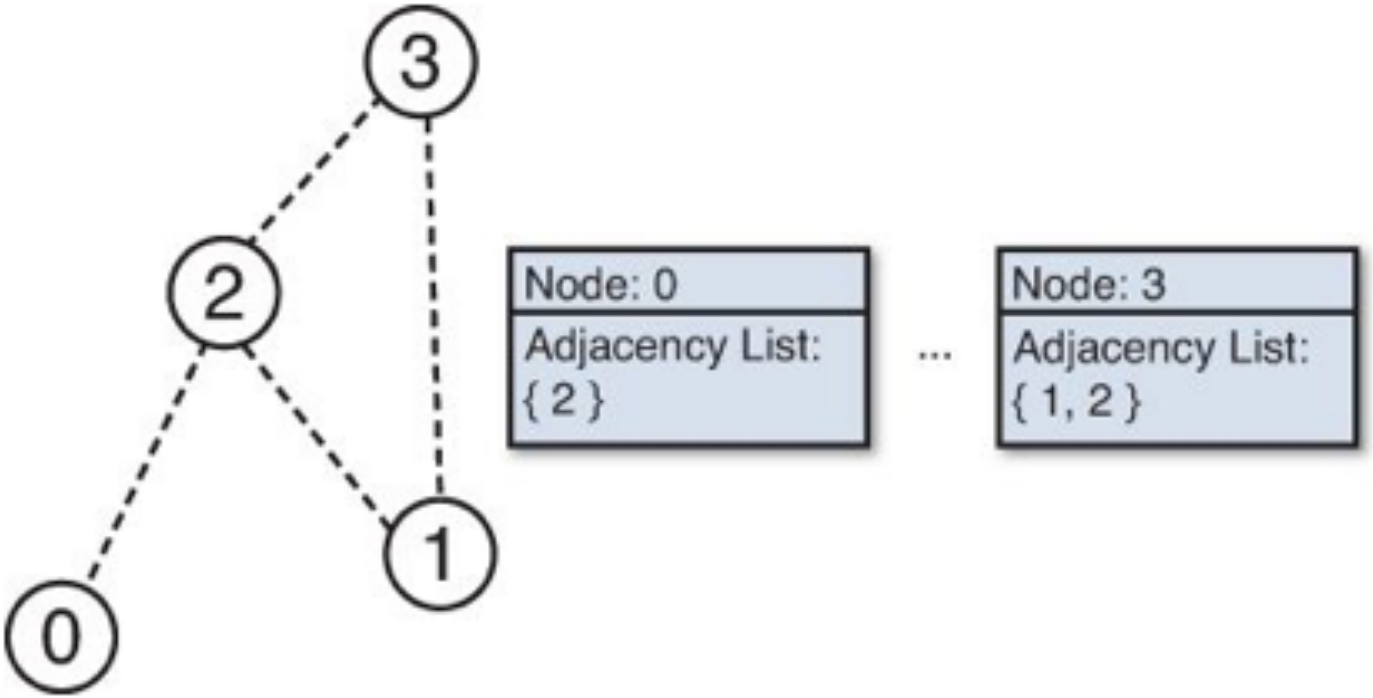
Path nodes et navigation meshes



Path nodes
(22 nodes, 41 edges)

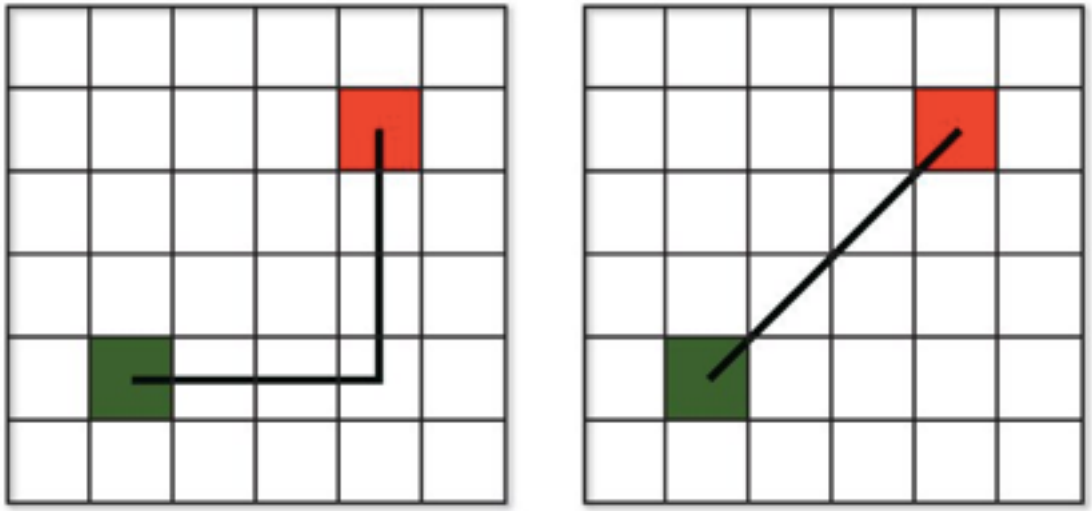
Navigation Mesh
(9 nodes, 12 edges)

Graphe de parcours



Recherche de plus courts chemins

- La longueur d'un chemin est supérieure à la distance de Manhattan, qui est supérieure à la distance Euclidienne



Manhattan Distance
h(x) = 6

Euclidean Distance
h(x) = 4.24

Arbre de parcours du graphe

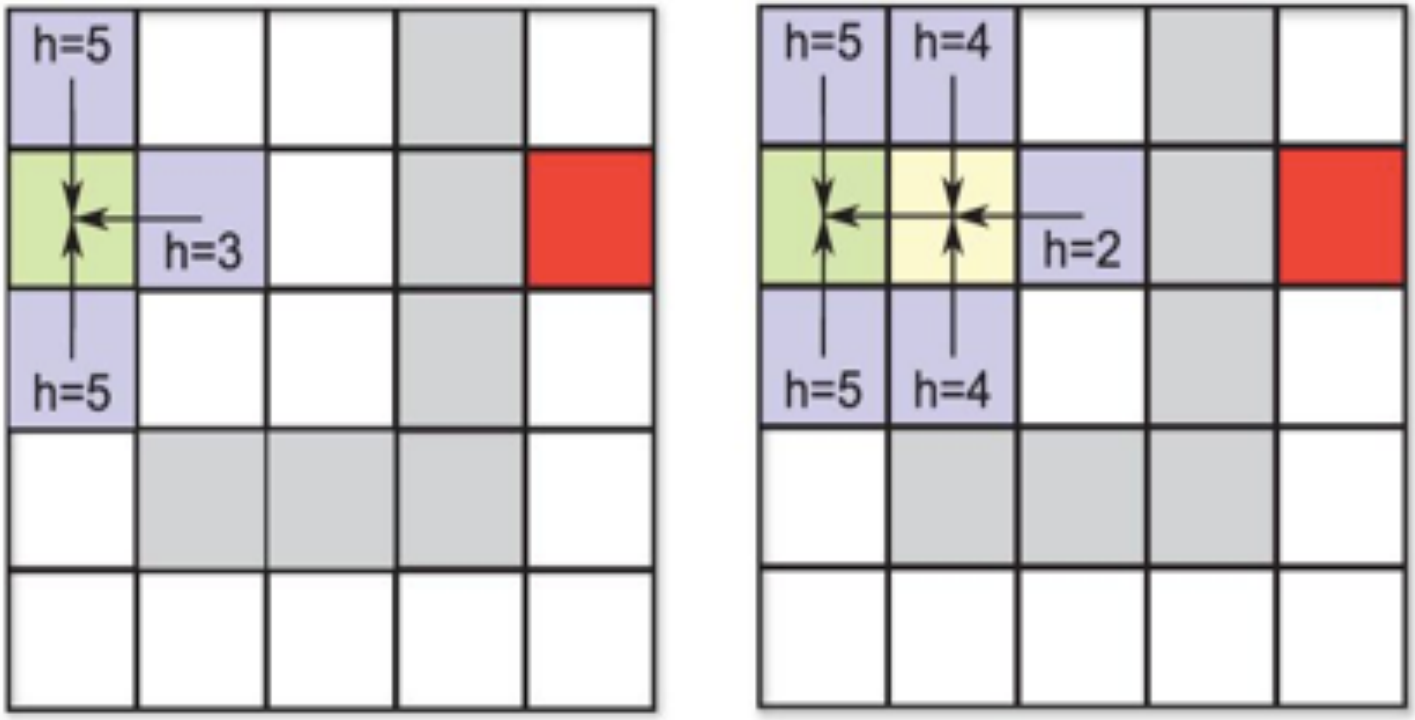
```
struct Node
    Node parent
    float h
end
```

- OpenSet : Noeuds à évaluer, par ordre de distance croissante (file de priorité)
- ClosedSet : Noeuds déjà évalués (arbre binaire)

Parcours « best-first »

```
do
   foreach Node n adjacent to currentNode
      if closedSet contains n
         continue
      else
         n.parent = currentNode
         if openSet does not contain n
            compute n.h
            add n to openSet
         end
      end
   loop //end foreach
```

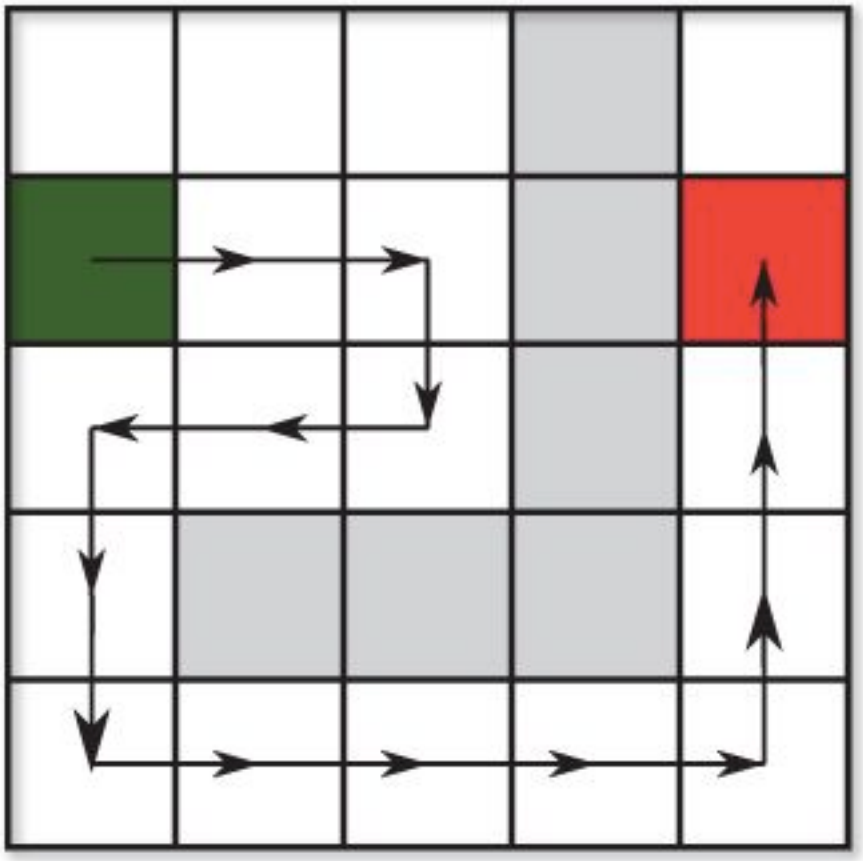
Parcours best-first



(a): First Iteration

(b): First Iteration

Recherche heuristique



Algorithme A*

- Meilleure estimation de la distance totale

$$f(x) = g(x) + h(x)$$

- Révision du meilleur chemin

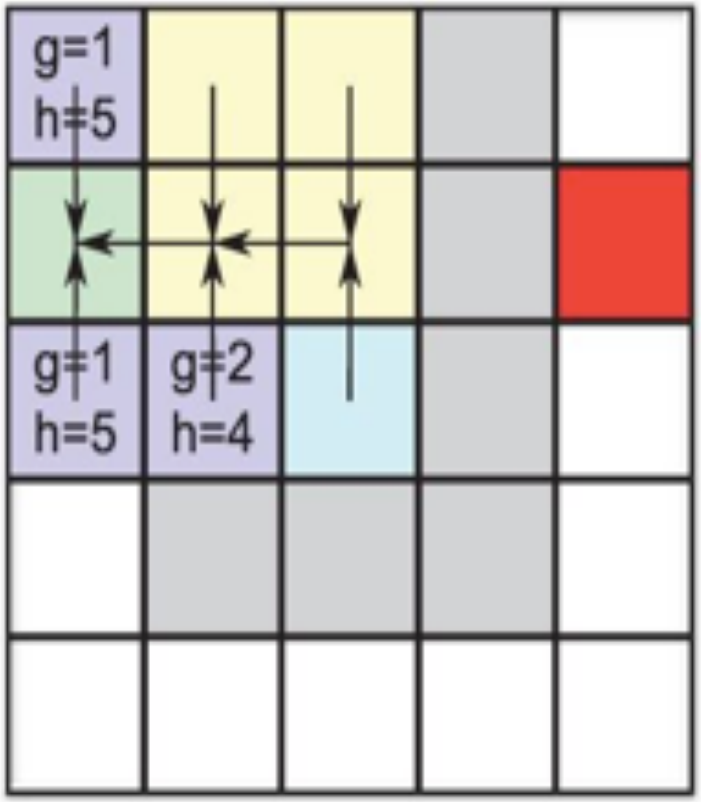
```
struct Node
    Node parent
    float f
    float g
    float h
end
```

Algorithme A*

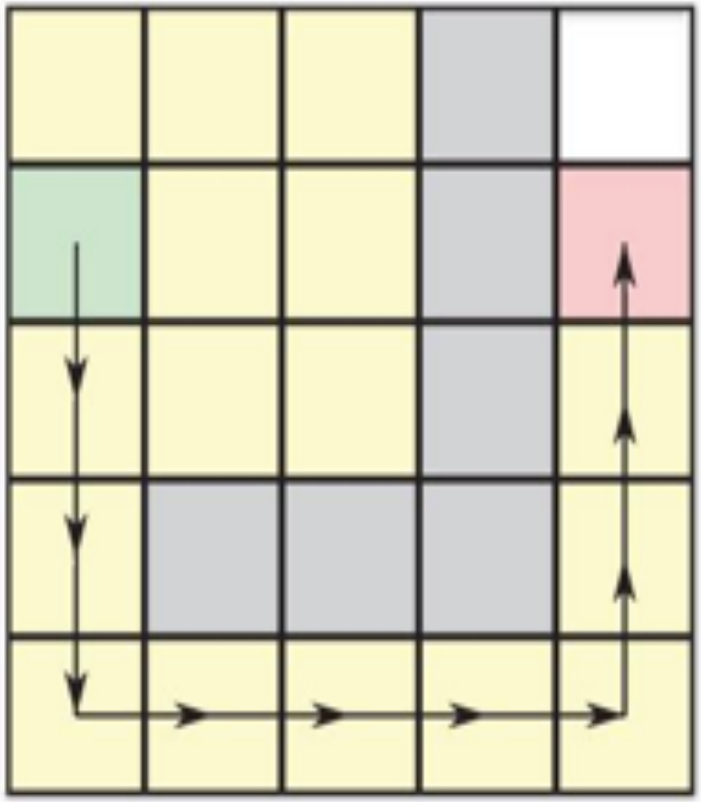
```
currentNode = startNode
add currentNode to closedSet
do
   foreach Node n adjacent to currentNode
      if closedSet contains n
         continue
      else if openSet contains n // Check for adoption
         compute new_g // g(x) value for n with currentNode as parent
         if new_g < n.g
            n.parent = currentNode
            n.g = new_g
            n.f = n.g + n.h // n.h for this node will not change
         end
      else
         n.parent = currentNode
         compute n.h
         compute n.g
         n.f = n.g + n.h
         add n to openSet
      end
   loop

   if openSet is empty
      break
   end
   currentNode = Node with lowest f in openSet
   remove currentNode from openSet
   add currentNode to closedSet
until currentNode == endNode
// Path reconstruction from Listing 9.1.
...
```

Exemple



(a): Current Node Adoption Fails



(b): Final A* Route

Algorithme de Dijkstra

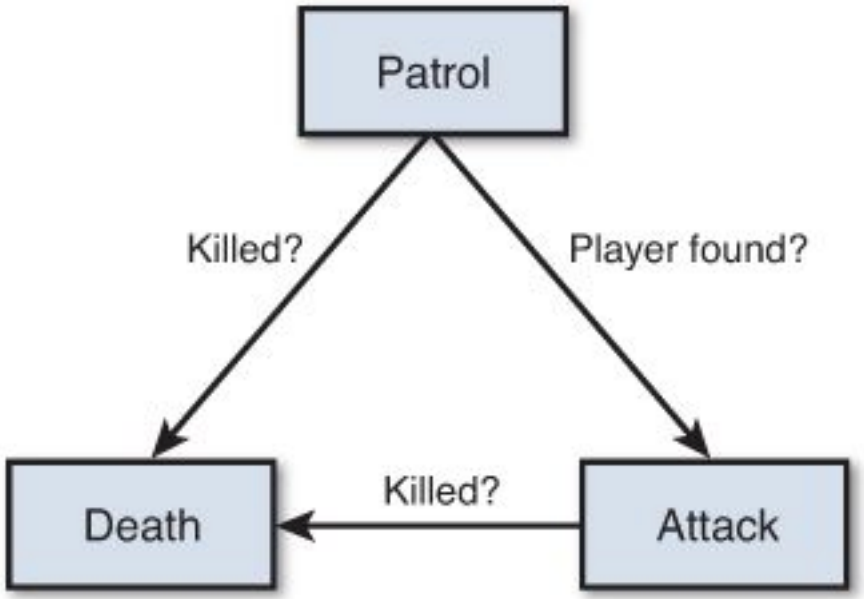
$$f(x) = g(x) + h(x)$$
$$h(x) = 0$$
$$\therefore f(x) = g(x)$$

- Avantage : trouve toutes les solutions
- Inconvénient : parcourt tous les chemins possibles

Machines d'états finis

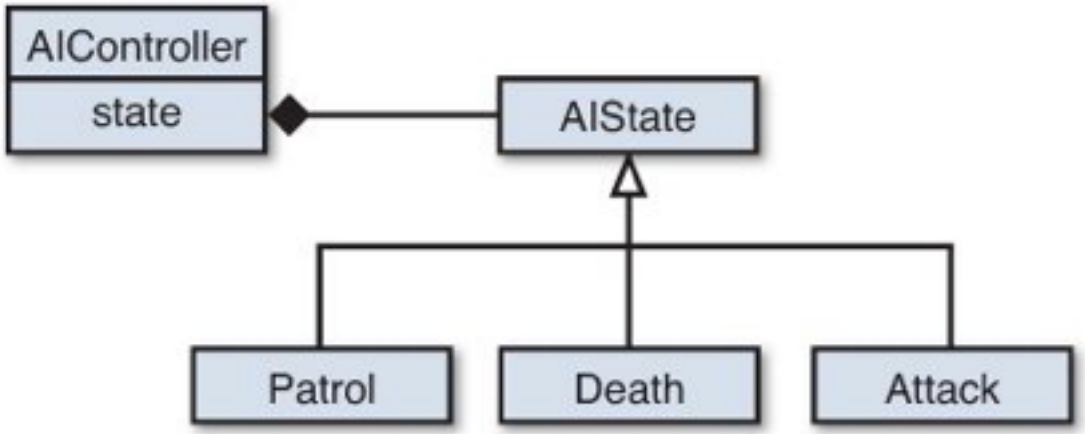
Exemple de machine d'états finis

```
function AIController.Update(float deltaTime)
    if state == Patrol
        // Perform Patrol actions
    else if state == Death
        // Perform Death actions
    else if state == Attack
        // Perform Attack actions
    end
end
```



Exemple d'implémentation

```
class AIState
    AIController parent
    function Update(float deltaTime)
     function Enter()
     function Exit()
end
```



Exemple d'implémentation

```
class AIController
    AIState state
    function Update(float deltaTime)
    function SetState(AIState newState)
end
```

```
function AIController.SetState(AIState newState)
    state.Exit()
    state = newState
    state.Enter()
end
```

Machines d'états finis hiérarchiques

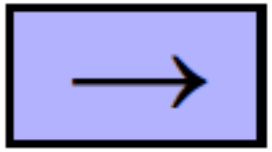
Arbres de comportements

- Utilisés dans Halo, Spore, etc.
- Décomposition hiérarchique des comportements (ET/OU)
- Décomposition séquentielle des comportements
- Branches de l'arbre sont des conditions à tester et des actions à exécuter

Arbres de comportements

Interior Nodes

- **Sequence node** *(similar to AND)*



- **Selector node** *(similar to OR)*

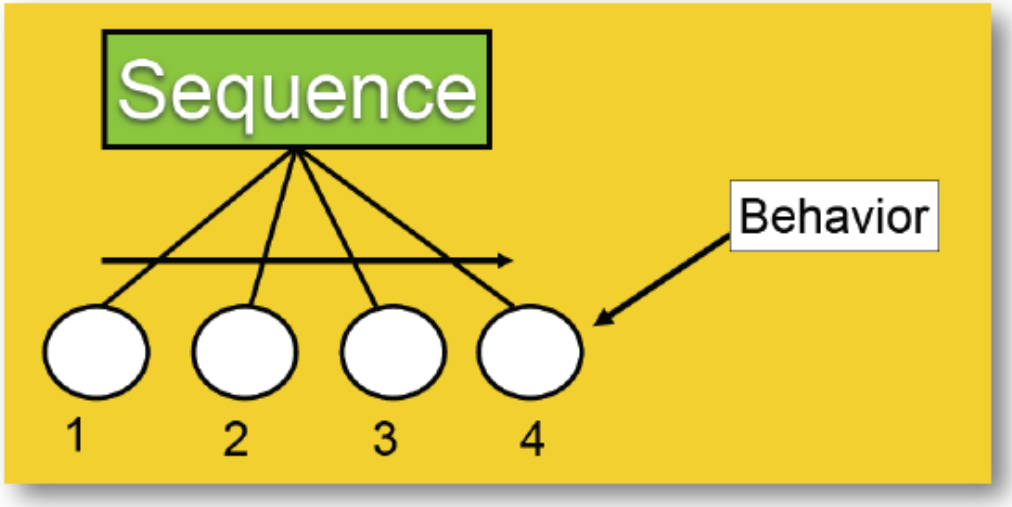
Leaf Nodes:

- Can be either *Conditions* or *Actions*
- are game-dependent
- Actions typically change the NPC or game state
- Conditions return true or false based on some check

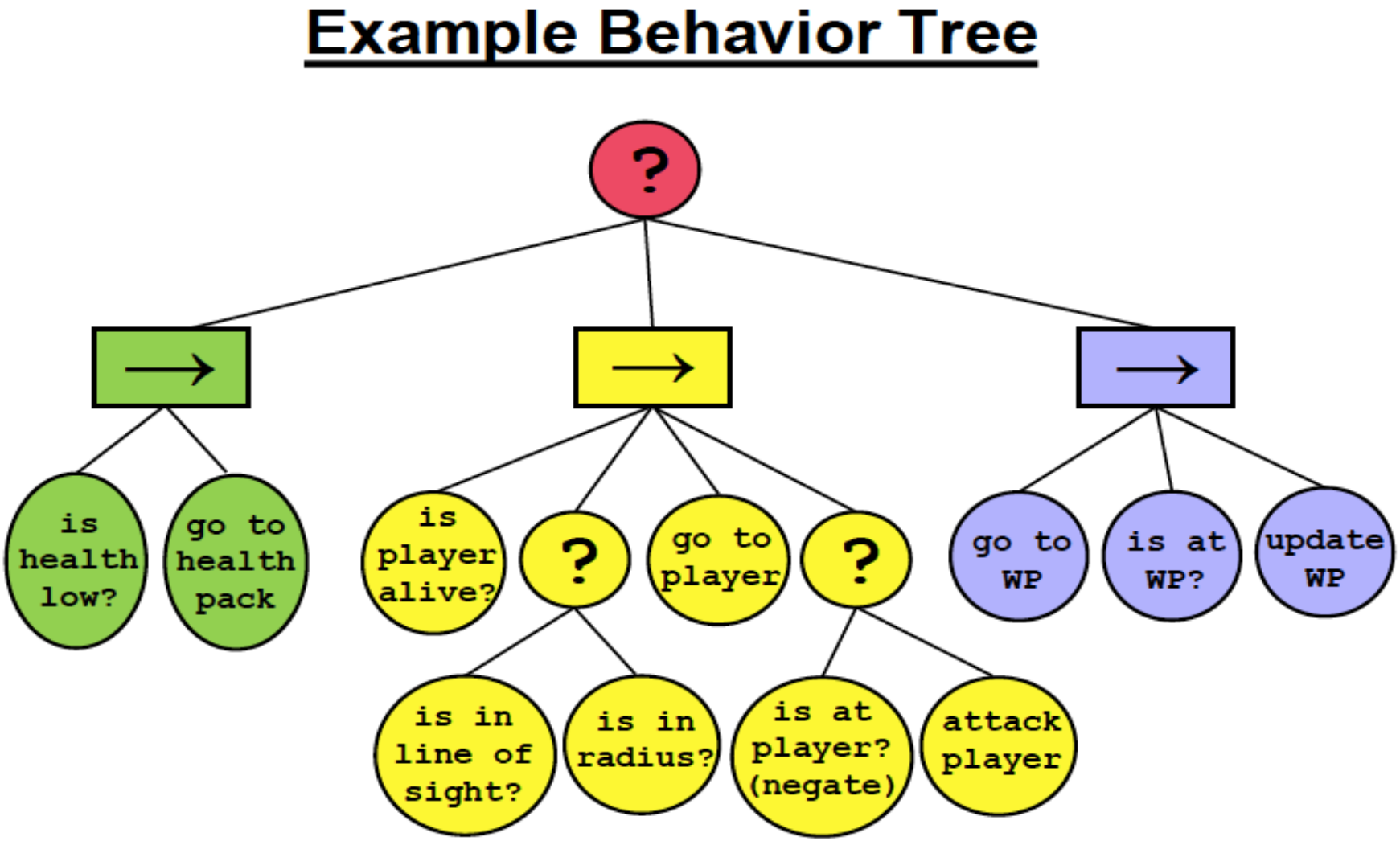
Arbres de comportements

Behavior Tree - Sequence

- Basic functionality:
- Child behavior succeeds ➔ sequence continues
- Child behavior fails ➔ sequence fails



Arbres de comportements



Cinématographie et montage intelligents

Virtual Cinematography
Theory and Practice for Automatic Real-Time Camera Control and Directing

By Liwei He, Microsoft Research

- http://research.microsoft.com/users/lhe

Intelligence artificielle des SIMS

- Modeling individual personalities (Richard Evans)

Emergent narrative : Alice and Kev by **Robin Burkinshaw**

Kev, the father, is mean-spirited and highly inappropriate

- **Alice, his daughter, is sweet, kind, forgiving**

Intelligence artificielle des SIMS

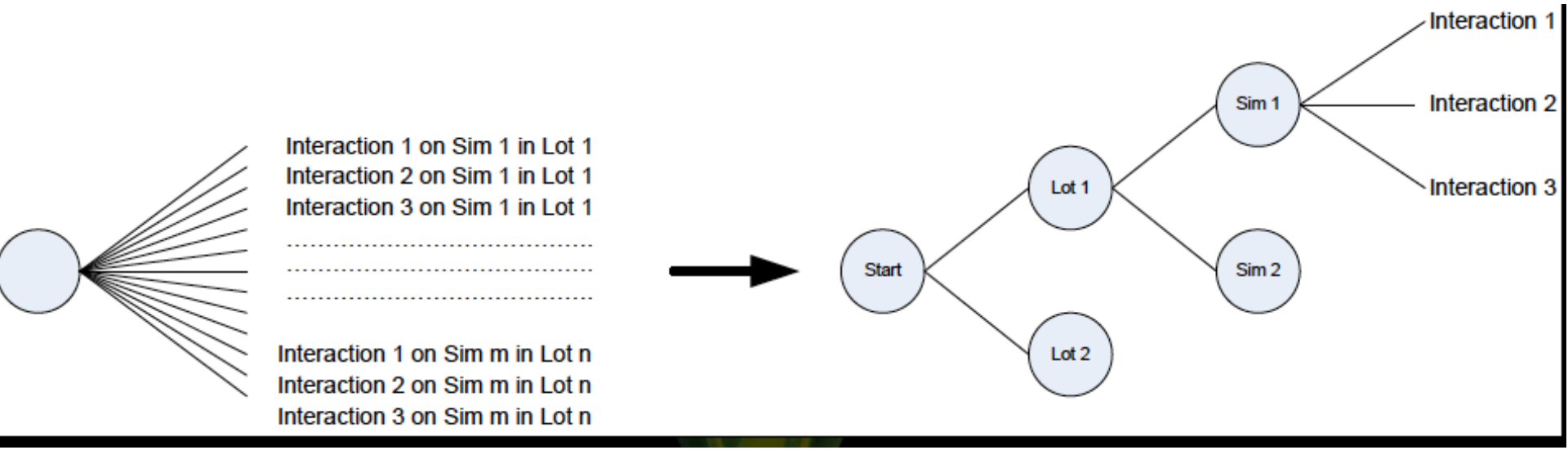
- Planification hiérarchique
- Carte des buts et interactions
- Décisions non déterministes
- Personalités et motivations
- Actes de langages et situations sociales
- Progression narrative et dramaturgie

Planification hiérarchique

- Réduire le nombre de choix

for each lot l
for each agent x in l
for each social interaction a on x
consider performing a on x

Choose which lot to go to: l
Then choose which agent to talk to in l : x
Then choose which social interaction to perform : a



Commodity-interaction maps

Sims 1 & 2 :

- **for each interaction a on each object x**
  - **check if a is currently available on x**
    - **if so, work out how much I want to do a**

Sims 3 :

Consulter une « carte » des buts (commodities) et actions associées

Commodities and interactions

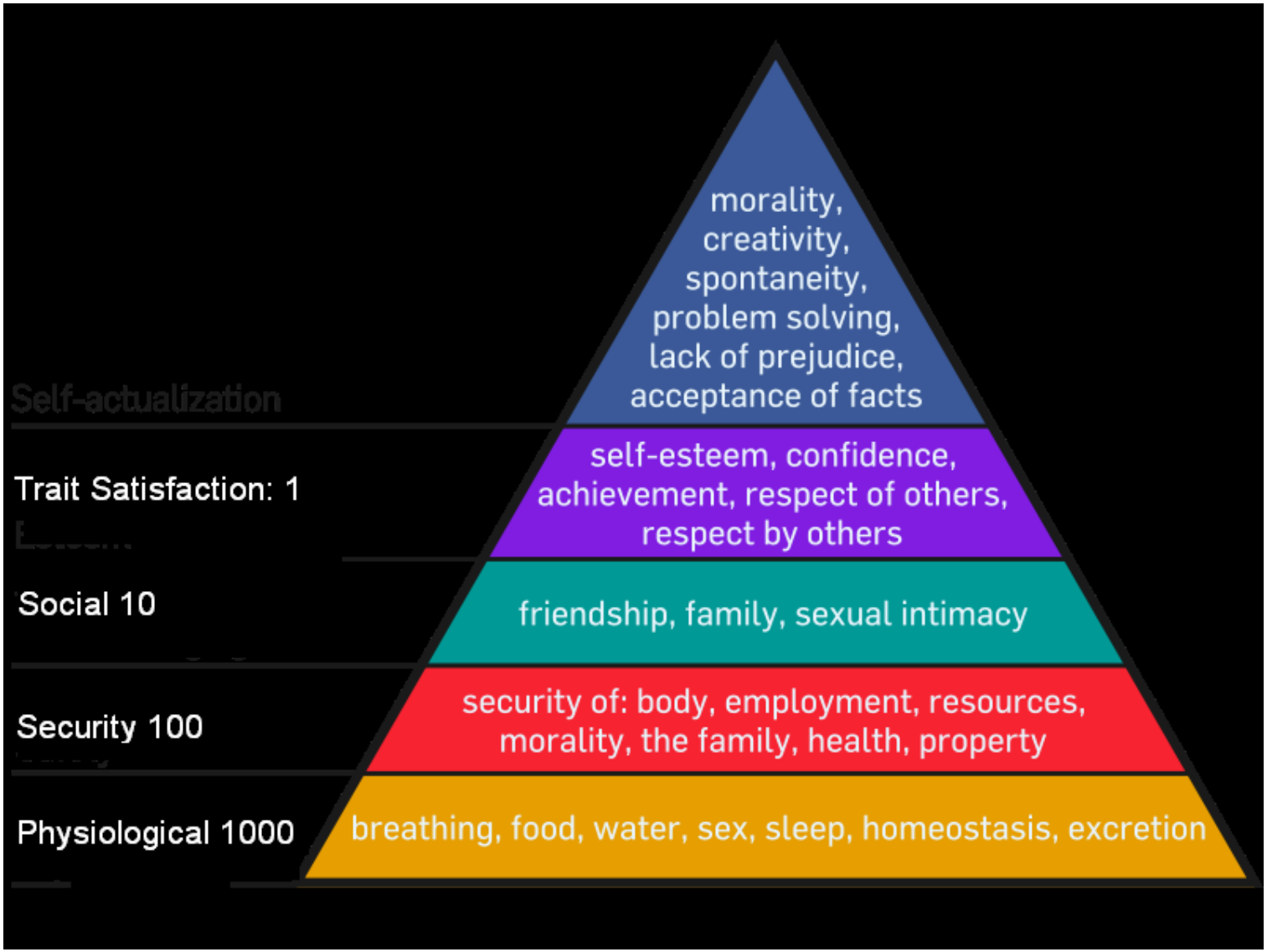
Commodity	Interactions
Bladder	Use(ToiletStall) Use(ToiletStall) Use(ToiletStall) Use(ToiletStall)
Hunger	Have Refreshing Drink(BarModern) Have Refreshing Drink(BarModern) (FridgeDrawer) (FridgeDrawer)
Energy	Nap(ChairLivingDesigner) Nap(ChairLivingDesigner) Drink Delicious Half-Caf Chocolate Lite Frothiccino with Caramel Spri
Hygiene	Take Shower(ShowerLoft) Take Bath(BathtubModern) Take Delightful Bubble Bath(BathtubModern) Take Shower(Shower
Fun	Pump Iron(WorkoutBench) Dance(StereoExpensive) Turn On(StereoExpensive) Strength Training(StereoExpensive) Take
Dirtiness	Clean(C4) Clean(C6) Clean(ShowerLoft) Clean(BathtubModern) Clean(ToiletStall) Clean(ToiletStall) Take Out Trash(Trash
Social	Train (WorkoutBench) (WorkoutBench) Train (StereoExpensive) (StereoExpensive) Train Buster(TVWall) (TVWall) Train (
ComeAndSee	Check Out New Object(Pool)
DaredevilOnDare	Take Shower(ShowerLoft) Take Shower(ShowerLoft) Take Shower(ShowerLoft) Take Shower(ShowerLoft)
ExtinguishSelf	Put Out Self(ShowerLoft) Put Out Self(ShowerLoft) Put Out Self(ShowerLoft) Put Out Self(ShowerLoft) ***** Gameplay/Abstract
SwimmingInPoolMotive	***** Gameplay/Abstracts/ScriptObject/GetInPool:InteractionName *****(Pool) Swim(Pool)
PrepareForParty	Clean(C4) Clean(C6) Clean(ShowerLoft) Turn On(StereoExpensive) Clean(BathtubModern) Clean(ToiletStall) Clean(ToiletS
BeHostAtParty	Make Refreshing Drinks(BarModern) Make Refreshing Drinks(BarModern) (FridgeDrawer) Serve Delightful Hot Beverage
ChildEnjoyParty	Play Video Game(TVWall)
TeenEnjoyParty	Dance(StereoExpensive) Turn On(StereoExpensive)
AdultEnjoyParty	Dance(StereoExpensive) Turn On(StereoExpensive)
PrepareForFuneral	Clean(C4) Clean(C6) Clean(ToiletStall) Clean(ToiletStall) Clean(ToiletStall) Clean(ToiletStall) Clean(C457) Clean(C458)
BeGuestAtFuneral	Sit(ChairDiningModerate) Sit(ChairDiningModerate) Sit(ChairDiningModerate) Sit(ChairLivingDesigner) Sit(ChairLivingDesi
StayAtVenue	Sit(ChairDiningModerate) Sit(ChairDiningModerate) Sit(ChairDiningModerate) Sit(BathtubModern) Sit(ChairLivingDesigner)
BeInGym	Pump Iron(WorkoutBench) ***** Gameplay/Abstracts/ScriptObject/GetInPool:InteractionName *****(Pool) Work Out(Treadmi
BeInArtGallery	View(UberBoxPedestal) View(SculptureVaseContemporary) View(SculptureVaseContemporary) View(SculpturePlantPhilo
BeAtSwimmingPool	***** Gameplay/Abstracts/ScriptObject/GetInPool:InteractionName *****(Pool) Swim(Pool) Relax(ChairLoungeModern) Rela
BeSuspicious	Look In Window(WindowFullContemporary2x1) Look In Window(WindowFullContemporary2x1) Look In Window(WindowFu
BeMaid	Clean(C4) Clean(C6) Clean(ShowerLoft) Clean(BathtubModern) Clean(ToiletStall) Clean(ToiletStall) Take Out Trash(Trash
BeRepairman	Repair Shower(ShowerLoft) Repair(StereoExpensive) Repair(BathtubModern) Unclog(ToiletStall) Unclog(ToiletStall) Uncl
KeepSwimming	Swim(Pool)
RelieveNausea	Vomit(ToiletStall) Vomit(ToiletStall) Vomit(ToiletStall) Vomit(ToiletStall)

Comment les SIMS décident-ils de leurs actions ?

- Calculer l'utilité (score) de toutes les actions possibles
- Choisir avec une probabilité p = exp(S/T) -1

- **T is the temperature**
- **This is a simplified Boltzmann function**
- **Temperature should be cool when he is happy, and should go up when the Sim is doing badly**

Hiérarchie des motivations de Maslow



Motivations et traits de personalité

- **In Sims 1 & 2, every Sim had the same 8 motives**
- **In Sims 3, each Sim has a different set of motives, based on his traits**
- **But the set of motives doesn't just vary between individuals, it also varies within the *same individual* over time**
- **We add and remove motives through time, to model a Sim's understanding of social norms**

Jeu vidéo et interaction sociale

- **Sims 1 and 2 had very broad speech-acts**
  - **Talk, Joke**
- **In Sims 3, we have more specific social speech-acts**
  - **Compliment Home, Worry About Relationship**
- **These fine-grained social speech-acts allow us to express our fine-grained personalities**

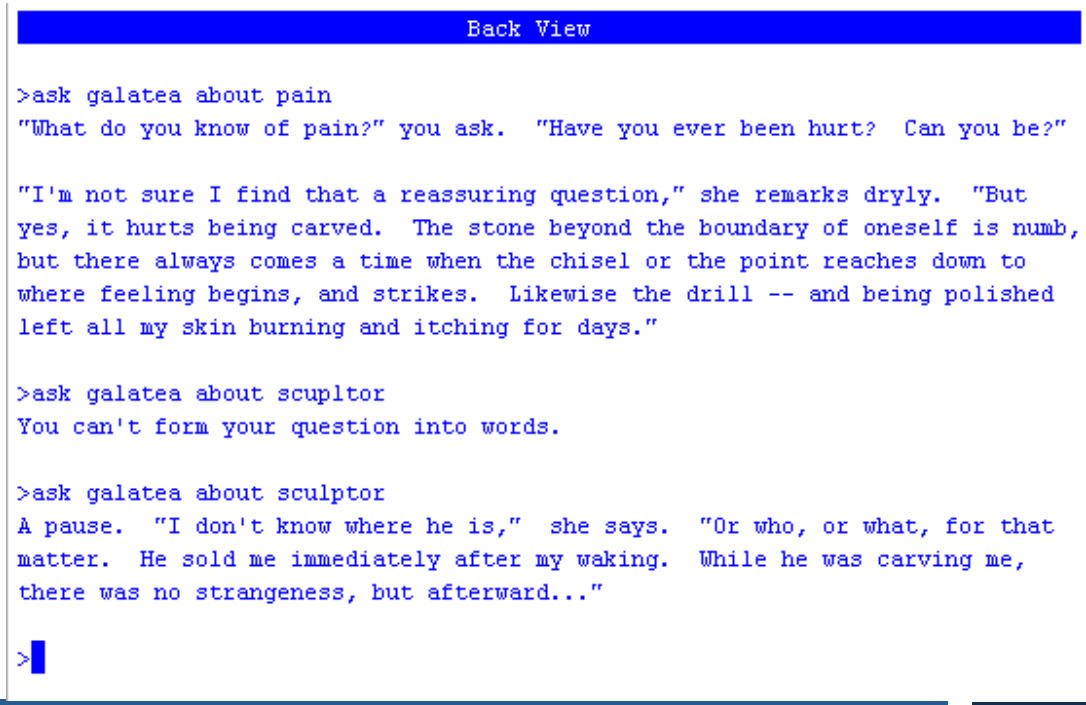
Traits affect which social interactions they choose autonomously

- Snobs like to boast about their cars
- Neurotic Sims will accuse their partner of cheating on them
- If a mean-spirited Sim finds out the person he is talking to is a vegetarian, he is apt to mock her vegetarianism!

Les SIMS agissent en fonction de leurs personnalités et des situations sociales

Fiction interactive et jeu vidéo

- **Inform 7 uses production rules as the fundamental unit of representation**
- **In some of Emily Short's work, the conversation is an end in itself.**



The field of computer graphics is more advanced than AI in games because graphics has a clean decomposition of form/function in terms of texture/polygon

Artists are free to add any texture they like

Graphics engineers deal with polygons

There is no analog in AI of the texture/polygon decomposition

Richard Evans

Pour aller plus loin