

# Newtonian Emotion System

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- Emotions are an important part of human communication (absence is noted and bothersome)
- Goal: create believable intelligent artificial characters capable of displaying affective behavior
- We attempt to provide artificial characters with an emotional layer serving adaptive ends
- Influence agent behavior by establishing the importance of events and by influencing knowledge processing
- Provide the agent with an emotional state that it will be able to express.
- Application: virtual characters in role-playing games



Figure : Basic emotions

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# Plutchik

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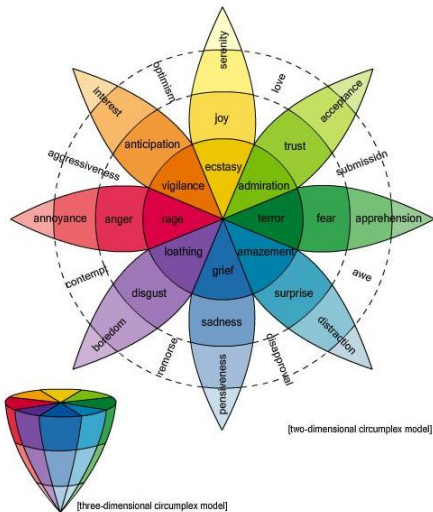


Figure : Plutchik's wheel of emotions

# Lazarus

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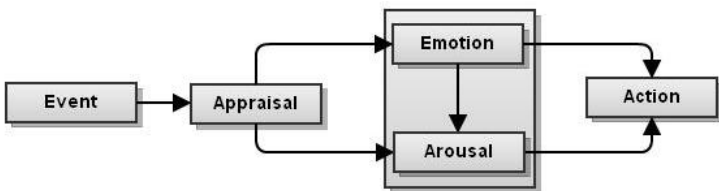


Figure : Lazarus' emotion synthesis model

# Perception

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Emotions influence how we process and store information (critical tool for adaptation and survival).

## Attention narrowing

Events and objects that hold a high level of emotional arousal for the subject are more likely to be processed in conditions of limited attention, and, emotions are used in the prioritized processing of such stimuli.



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# Newtonian emotion space

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### Definition

**Position** specifies the intersection of an emotional state with each of the four axes

### Definition

**Distance** ( $\|\vec{p}_2 - \vec{p}_1\|$ ) measures the distance between two emotional *positions*

### Definition

**Velocity** ( $\vec{v} = \frac{\vec{p}_2 - \vec{p}_1}{t}$ ) represents the magnitude and direction of an emotion's change of *position* within the emotion space over a unit of time

### Definition

**Acceleration** ( $\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{t}$ ) represents the magnitude and direction of an emotion's change of *velocity* within the emotion space over a unit of time

### Definition

**Mass** represents an emotional state's tendency to maintain a constant velocity unless acted upon by an external force; quantitative measure of an emotional object's resistance to the change of its velocity

### Definition

**Force** ( $\vec{F} = m \cdot \vec{a}$ ) is an external influence that causes an emotional state to undergo a change in direction and/or velocity

# Laws of emotion dynamics

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## Theorem

*The velocity of an emotional state remains constant unless it is acted upon by an external force.*

## Theorem

*The acceleration  $\vec{a}$  of a body is parallel and directly proportional to the net force  $\vec{F}$  and inversely proportional to the mass  $m$ :  $\vec{F} = m \cdot \vec{a}$*

# Emotion center and gravity

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## Emotion center

- Represents the agent's neutral emotion state.
- The agent's state is drawn to this point in emotion space.
- Emotion mass influences the speed with which states change.

## Emotion gravity

$$\vec{G} = m \cdot \frac{\vec{p} - \vec{c}}{\|\vec{p} - \vec{c}\|} \cdot k_g,$$

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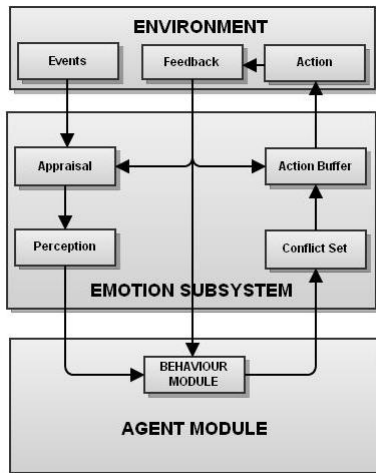


Figure : Emotion system architecture

# Action

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The action whose emotion vector most closely matches the agent's current state is selected to be carried out.

## Conflict resolution

$$\arg \min_{i \in \{\text{conflictset}\}} \arccos \frac{e_{\text{agent}} \cdot e_i}{\|e_{\text{agent}}\| \cdot \|e_i\|}$$

# Learning

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- The appraisal and conflict set modules use machine learning techniques
- Plug-and-play model where the technique can be replaced (hidden markov models, neural nets, q-learning)
- Both modules attempt to predict emotional feedback received from the environment
- Goal of the appraisal module: to better label events for the perception module
- Goal of the conflict set module: to settle conflicts between competing actions (lowest emotional distance)



# Parameters

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## Center

Character's basic disposition

## Mass

Character's resistance to change

## Personality

The personality filter skews a character's perception

# Motivation

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## Emotions motivate character behavior

emotional impact measures the stress that a certain action will cause on the agent's current state

- *tensor product between the current gravity and the feedback force*

## Metrics

- Gain - measures the effect on the Joy and Trust axes
- Risk - represents the effect on the Fear and Surprise axes

$$Impact = \frac{Gain}{Risk}$$

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- Main goal: provide virtual characters with the ability of emotion expression
- Emotions act as a subsystem that enhances human behavior (as in humans)
- A light-weight and scalable emotion representation and evaluation model
- Suitable for fast real-time evaluation and simulation
- Plug and play emotion subsystem architecture (any agent behavior module, any machine learning technique)

# Collective emotions

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- Application of the model in a multi-agent system context (e.g. swarm or ambient intelligence)
- Agents influence each other's emotions through observation - collective / contagious mood
- Ambient intelligence applications (emotion dissemination, influence people)
- Provide non-invasive feedback on ambient intelligence network state

# Thank you!

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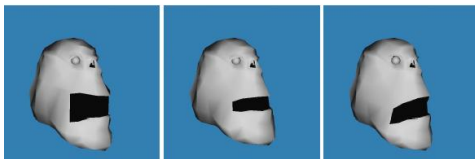
Future work



(a) Anticipation

(b) Joy

(c) Trust



(d) Anger

(e) Neutral

(f) Fear



(g) Disgust

(h) Sadness

(i) Surprise