Imperial College London

COMPUTATIONAL Creativity Group

Computational Creativity Autumn School

Lecture 1

Introduction to

Computational Creativity

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Check us out...

ccg.doc.ic.ac.uk

- Computational Creativity Group at Imperial
  - Six PhD students, Four PostDocs and Me
- AI research, where we study fundamental notions of creativity in software via applications to:
  - Graphic design, mathematical discovery, the visual arts and video game design

Overview

- The aim of this lecture is to give you an introductory flavour to this cutting edge research topic

- Introductory definitions, aims, objectives, domains
- Quick look at some creative systems (past+present)
- First main issue: generative processes
- Second main issue: evaluating creativity

Computational Creativity

Definitions

- The sub-area of AI research, where we study how to build software which exhibits behaviour that would be deemed creative if exhibited by a person

- The study of how to build software which takes on some of the creative responsibility in arts and science projects

- Not just the usage of computers in creative tasks

Computational Creativity

Aims

- To build autonomously creative software, for practical purposes, or as an intellectual challenge
- To help us to understand more about human creativity, via computational models
- To help people to become more creative, via the building of collaborative creative systems
- To stretch existing AI systems (and combinations thereof) to breaking point, and suggest improvements

Be Slightly Afraid...

- In the past, words such as *creativity, emotion, self-awareness,* etc., were used to beat AI researchers with
  - So there is still some resistance in the AI world to creativity research
  - "Truly creative thinking of course will always remain beyond the power of any machine" (Meccano magazine June 1934)
- And even more mis-understanding (denial...?) outside of AI circles
  - E.g., Strothotte and Schlectweg in *'Non-photorealistic Computer Graphics'*: "Simulating artistic techniques means also simulating human thinking and reasoning, especially creative thinking. This is impossible to do using algorithms or information processing systems"
- And it gets even worse when journalists come along:
  "Is this some kind of hellish nightmare...?" (More4 News, Sept. 2006)
  - Reporting on a computer art exhibition

Application Domains

- Linguistics: generation of jokes; poems; plot lines; neologisms; acronyms; dialogue; stories;
- Music: melodies; harmonisations; structures; compositions; accompaniments; interactive systems;
- Visual arts: evolutionary art; scene generation; automated painting; pixel shading; mathematical art;
- Pure mathematics: concept invention; conjecture making; theorem proving;
- Other domains: science (in particular bioinformatics); video game design (e.g., level generation), ...

A Sampling of

Early Named Systems

- Doug Lenat's *AM* (1975 - 1985)
  - Automated mathematician
- Harold Cohen's *AARON* (1973 - today)
  - Automated painter
- David Cope's *EMI* system (1981 - 2005)
  - Automated composer
- William Chamberlain and Thomas Eiter's *Racter* (1984-1986)
  - Automated poet

Sample Output

- AM re-inventions:
  - Goldbach's conjecture, highly composite numbers

- From Racter:

> More than iron, more than lead, more than gold I need electricity.
> I need it more than I need lamb or pork or lettuce or cucumber.
> I need it for my dreams. Racter, from *The Policeman's Beard Is Half Constructed*

Sample Output

- AARON

A Sampling of

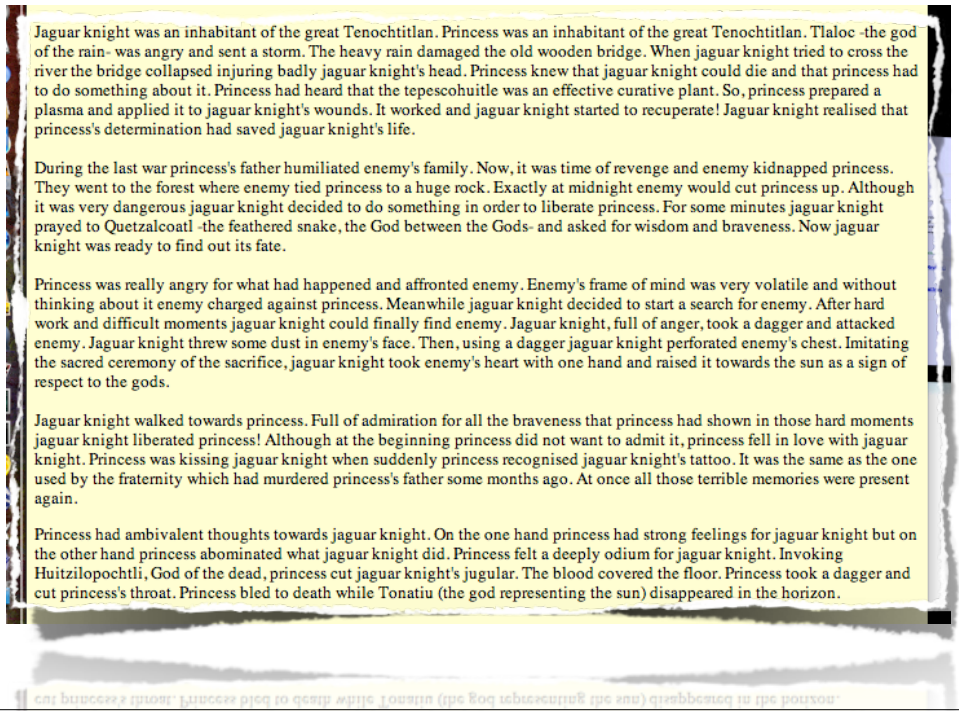
More Recent Named Systems

- Penousal Machado's *NEvAr* (2000 - today)
  - Evolutionary artist
- Francois Pachet's *Continuator* System (2001 - today)
  - Automated live musician
- Kim Binsted + Graeme Ritchie's *Jape* (1995 - today)
  - Automated joke teller
- Rafael Perez y Perez's *Mexica* (1999 - today)
  - Automated story teller
- Pablo Gervas's *ASPERA* (2000 - today)
  - Automated poet

Sample Output

Mexica Story

www.rafaelperezyperez.com/MEXICA



Jaguar knight was an inhabitant of the great Tenochtitlan. Princess was an inhabitant of the great Tenochtitlan. Tlaloc -the god of the rain- was angry and sent a storm. The heavy rain damaged the old wooden bridge. When jaguar knight tried to cross the river the bridge collapsed injuring badly jaguar knight's head. Princess knew that jaguar knight could die and that princess had to do something about it. Princess had heard that the tepescohuitle was an effective curative plant. So, princess prepared a plasma and applied it to jaguar knight's wounds. It worked and jaguar knight started to recuperate! Jaguar knight realised that princess's determination had saved jaguar knight's life.

During the last war princess's father humiliated enemy's family. Now, it was time of revenge and enemy kidnapped princess. They went to the forest where enemy tied princess to a huge rock. Exactly at midnight enemy would cut princess up. Although it was very dangerous jaguar knight decided to do something in order to liberate princess. For some minutes jaguar knight prayed to Quetzalcoatl -the feathered snake, the God between the Gods- and asked for wisdom and braveness. Now jaguar knight was ready to find out its fate.

Princess was really angry for what had happened and affronted enemy. Enemy's frame of mind was very volatile and without thinking about it enemy charged against princess. Meanwhile jaguar knight decided to start a search for enemy. After hard work and difficult moments jaguar knight could finally find enemy. Jaguar knight, full of anger, took a dagger and attacked enemy. Jaguar knight threw some dust in enemy's face. Then, using a dagger jaguar knight perforated enemy's chest. Imitating the sacred ceremony of the sacrifice, jaguar knight took enemy's heart with one hand and raised it towards the sun as a sign of respect to the gods.

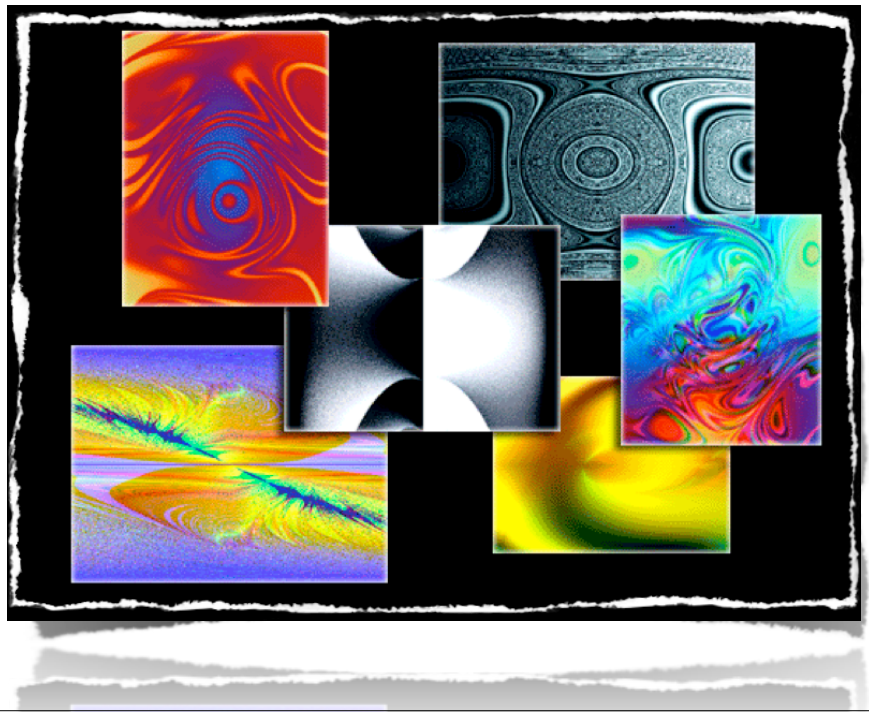
Jaguar knight walked towards princess. Full of admiration for all the braveness that princess had shown in those hard moments jaguar knight liberated princess! Although at the beginning princess did not want to admit it, princess fell in love with jaguar knight. Princess was kissing jaguar knight when suddenly princess recognised jaguar knight's tattoo. It was the same as the one used by the fraternity which had murdered princess's father some months ago. At once all those terrible memories were present again.

Princess had ambivalent thoughts towards jaguar knight. On the one hand princess had strong feelings for jaguar knight but on the other hand princess abominated what jaguar knight did. Princess felt a deeply odium for jaguar knight. Invoking Huitzilopochtli, God of the dead, princess cut jaguar knight's jugular. The blood covered the floor. Princess took a dagger and cut princess's throat. Princess bled to death while Tonatiu (the god representing the sun) disappeared in the horizon.

The Princess who Cured the Jaguar Knight.

Sample Output

NEvAr Pictures



A Sampling of Current

Named Systems

From our Group

- HR system (1996)
  - Mathematical discovery system
- The Painting Fool (2005)
  - Automated Painter (www.thepaintingfool.com)
- GC (2006)
  - Combined reasoning platform
- Filter Feast (2007)
  - Image Filter based platform
- LUDI (2008)
  - Evolutionary board game designer
- ELVIRA (2009)
  - Evolutionary art system
- ANGELINA (2010)
  - Evolutionary arcade game designer
- MOGAL (2010)
  - General game playing engine

Two Main Issues

- Achieving creativity in artefact generation
  - AI techniques employed and methodological issues
- Scientifically assessing progress towards creativity in individual computational systems
  - Assessing the artefacts
  - Assessing the processes

Artificial Intelligence Paradigms

- Problem solving paradigm (most of AI research)
  - An intelligent task is interpreted as a set or sequence of problems to be solved by individual problem solving agents
  - Specialist problem solvers are employed, such as theorem provers, planners, machine learning systems, constraint solvers, etc.
  - Occasionally, combinations of reasoning systems are used for greater power
- Artefact generation paradigm (computational creativity research)
  - An intelligent task is interpreted as a desire to generate something of cultural value, whether of aesthetic and/or utilitarian value
  - Specialist generative techniques and artefact evaluation modules are employed, such as evolutionary methods, conceptual blending, fitness functions, etc.
  - Occasionally, mash-ups are used for greater creative potential
- Big philosophical difference: problem solving agents are designed to think for us, whereas artefact generation agents are designed to make us think more.

Minor AI Methods in Computational Creativity

- AI methods tend to be for problem solving
- Some simply say yes or no, others bring new information into being
- These include *constraint solvers* (finding models) *theorem provers* (discovering proofs) and *machine learning systems* (inventing classifiers)
  - All of these are used as component systems to some extent in certain creative systems
  - For instance: constraint solvers are used in music harmonisation systems; machine learning systems learn certain musical styles, and theorem provers are used in mathematical discovery tasks

Major AI Methods and Methodologies in Computational Creativity

- Methods
  - Evolutionary programming
  - Case-based reasoning
  - Conceptual blending
- Methodologies
  - Analogical and metaphorical reasoning
  - Combining systems
  - Handing over creative responsibility

AI Methods

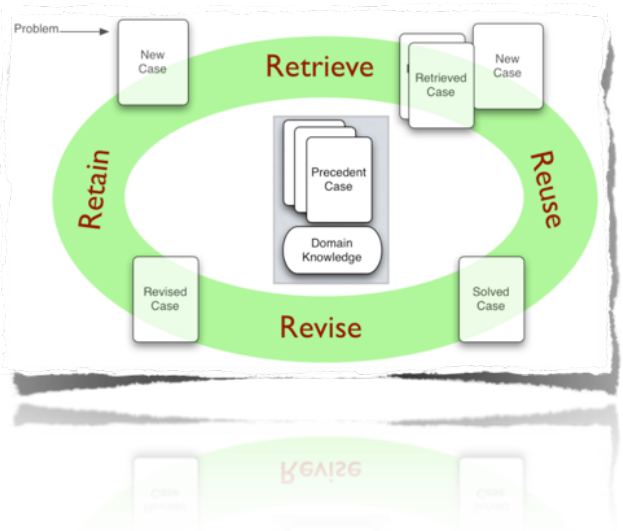
Evolutionary Approaches

- Programs (often represented as trees) are evolved at the genotype level, artefacts are produced by the programs at the phenotype level
  - By appealing to evolutionary processes such as crossover, mutation, survival of the fittest
- Works well for creative tasks because:
  - Often, very little domain knowledge is required, OK if "you know what you like"
  - The evolution often tends to produce surprising solutions (artefacts)
  - Fitness functions can be defined which have utilitarian and aesthetic aspects
  - Fitness can also be supplied entirely by the user (user-driven evolutionary approach)
  - Lends itself to higher level reasoning, e.g., invention of fitness functions
- Drawbacks: can be difficult to drive evolution; can take a long time to converge
- Examples of usage: entire workshops on EvoMusArt and EvoGames, scientific discovery

AI Methods

Case-based Reasoning

- Solve current problem by appealing to previous cases which worked
  - Four step process of retrieval, re-use, revision and retention
- Works well for creative tasks because it appeals to a set of known high value artefacts and alters them to fit the current context, hence likely to yield interesting and valuable artefacts
- Drawbacks: requires the building of a large case-base; could be seen as producing only pastiches of other people's work
- Example of usage: MuzaCazUza system by Ribeiro, Pereira, Ferrand and Cardoso:
  - Composition of melodies based on previous ones



http://cbrwiki.fdi.ucm.es/wiki/

AI Methods

Conceptual Blending

- Theory from cognitive linguistics
  - Attempts to explain aspects of human linguistic reasoning. Blending of concepts from different spaces. (Fauconnier and Turner). Example: horse and bird concepts blend to give Pegasus
- Works well for creative software because it is cognitively plausible and can lead to surprising conceptual blends
- Drawbacks: doesn't discuss where the conceptual spaces come from in the first place
- Examples of usage:
  - Linguistic creativity: neologisms
  - Creature generation for video game design (see next slide for an example)
  - Part of a proposed pedagogical model for children learning through video game playing (www.johnseelybrown.com/playimagination.pdf)

> To explain it in some detail, we must introduce the concept of Mental Space. According to [1], Mental Spaces are partial structures that proliferate when we think and talk, allowing a fine-grained partitioning of our discourse and knowledge structures. As we talk or think, our reasoning focus flows from space to space, transporting and mapping concepts according to points of view, presuppositions, beliefs, changes of mood or tense, analogical counterfactuals and so on, each giving birth to a different mental space.

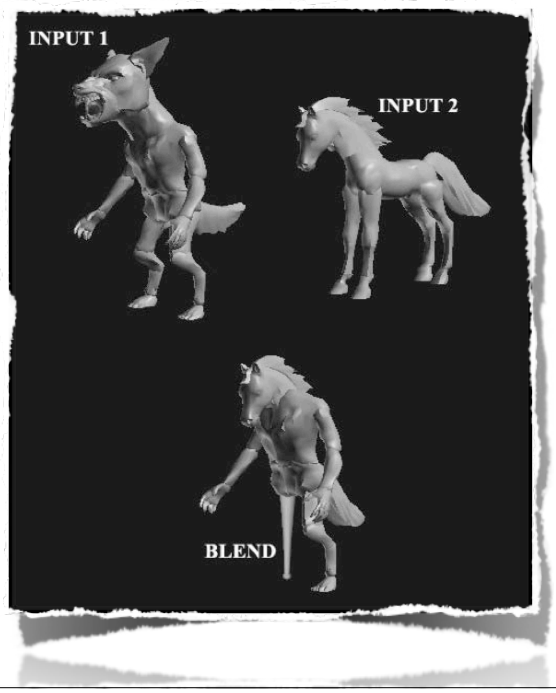
> Blending is generally described as involving two input mental spaces that, according to a given structure mapping, will generate a third one, called Blend. This new domain will maintain partial structure from the input domains and add emergent structure of its own.

From: *"Conceptual Blending and the Quest for the Holy Creative Process"* by Pereira and Cardoso (http://eden.dei.uc.pt/~camara/files/QuestCRC.pdf)

AI Methods

Conceptual Blending

Application to Creature Design for Games



From: P. Ribeiro, F. C. Pereira, B. Marques, B. Leitao and A. Cardoso, *"A model for creativity in creature generation"*, in Proceedings of the 4th Conference on Games Development (GAME ON'03), 2003

Methodological Issue #1

Metaphor and Analogy

- All good artists "steal", whereas scientists "stand on the shoulders of giants..."
  - All of cultural activity can be seen as a progression based on past work
- Metaphorical and analogical reasoning has strong creative potential in people
  - Many psychological and CogSci studies
- The three previous techniques can be seen as analogy driven (children are based on parents; previous cases and concepts are used to generate new artefacts)
- When building creative systems, consider whether they can:
  - Learn styles or methods from others (people or systems)
  - Build new artefacts from old ones
  - Take previous successful reasoning schemes and apply them in new situations
- See Hofstadter, Thagard, Veale, Barnden, ...
  - Particularly in linguistic creativity

Methodological Issue #2

Combining Systems

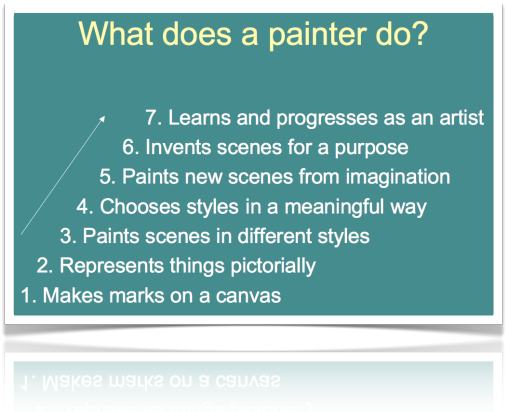
- Individual methods, etc., are designed for one thing, sometimes with multiple techniques available from within a single GUI (e.g., Photoshop)
  - Entirely driven by the user's aesthetic and utilitarian choices
- If we want autonomously creative systems, we have to enable them to use many different pieces of software, just like we do...
- Ultimately, the whole should be more than the sum of the parts:
  - More ability; more efficiency; more flexibility; more novelty and surprise
- When building creative systems, consider whether:
  - You are re-inventing the wheel, by implementing techniques that have been previously developed
  - You could achieve your aim by combining existing AI/Multimedia/etc. software in a mash-up
  - You can use a systematic combination method (e.g., multi-agent systems), rather than building ad-hoc software
  - Your combined system can be used for tasks which you didn't previously consider (perhaps by changing a module)

Methodological Issue #3

Handing over Creative Responsibility

- Ultimately, we want more than mere creativity support tools
  - We already have loads of great human artists, scientists, musicians, writers, etc.
  - There is the potential for creative software to add to our cultural life in new, interesting, surprising and unforseen ways
- Climbing the meta-mountain
  - This involves successively asking: "How am I using this software tool for my creative purposes? Can I get the software to do that itself? How can I implement those behaviours?"
  - Practically involves implementing more skills and critical abilities (to take over aesthetic responsibilities)

Meta-mountain for The Painting Fool



Assessing Creativity

- It's very difficult to assess creativity in people, animals and computer systems, so why bother?
  - To enable us to progress, by comparing new versions of creative systems to older versions - and to show a progression
  - To compare and contrast generic generative techniques, to see which is the best under which circumstances
  - To address our critics with arguments about why the software should be considered creative
  - To help clarify failings and implement better techniques
- Two main approaches to assessment:
  - Assess the artefacts produced; assess the underlying process

Assessing Artefacts

- See Graeme Ritchie's talk (next) for further details about his formalisation and that of Boden and of Wiggins
- In some domains, how artefacts were generated is much less important than the value of the artefacts themselves
  - E.g., jokes, mathematical theorems, scientific discoveries
  - However, when you hear a racist joke, if it is told by someone of that race, you might laugh; if it is told by someone else, you probably won't laugh...
- It's possible to think of innovation at the process level as being artefact generation at the meta-level: the artefact is the new process, which can be assessed as output
  - But it's not clear to me that it's useful to do this
- And I don't like it when researchers talk about "creative artefacts" to mean "creatively produced artefacts", as it's possible for software to produce artefacts which are themselves creative

Assessing Creative Processes

- In many domains, aspects of the cognitive and practical processes used to create an artefact are taken into account when assessing that artefact
  - In particular modern art, e.g., Duchamp's urinal
  - Especially the creativity involved in the production, which leads to a vicious circle in computational creativity, as the general impression is a lack of creativity
- One solution: manage the perception of creativity that people have, addressing their criticisms with specific implementations
  - Eventually, people will have to admit that software is creative because they cannot argue otherwise
- Creativity tripod: main arguments of criticism are along three axes:
  - Skill, appreciation and imagination
  - We can pro-actively implement behaviours to increase intelligence in these areas
- See my lecture on the formalisation of creative behaviour in software (FACE+IDEA)

The Wundt Curve

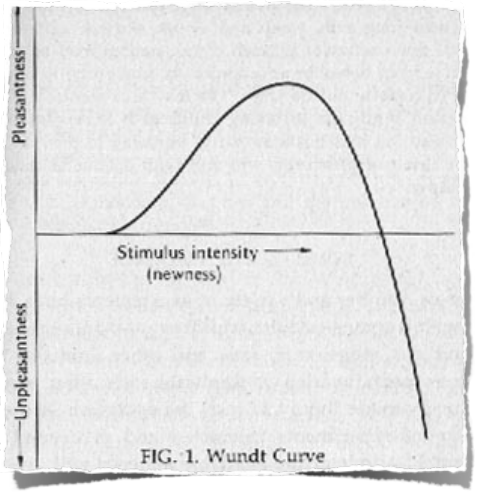


FIG. 1. Wundt Curve

- In exploratory creativity, some novelty is required to maximise hedonistic value, but too much is off-putting
- But is this how the cubists, or the abstract expressionists changed our view of representation art? Did they instead move the axes?

To Turing Test...
... or Not to Turing Test?

- Creative abilities in software differ between domains
- In some domains, producing human-quality artefacts is still quite difficult, especially in linguistic domains, perhaps because of the information density and lack of robustness of the written word (mistakes may be more easily tolerated in art, music and science domains)
    - In such difficult domains, it makes some sense to compare computer generated artefacts with human ones as in a Turing test, e.g., if people agree that Jape's joke are indistinguishable from joke-book jokes, this is a success
- However, when software passes the milestone of being able to produce culturally valuable artefacts that a person might not be able to produce, is the Turing test still a good way to assess its value?
    - An easy criticism of software like photoshop is that it produces only pastiches
    - And wouldn't an art school graduate be horrified if someone could not tell their work apart from another artist?
- Ultimately, software should surprise us, which might go against a Turing test...

Summary

- Creative software is out there
  - Working in artistic, scientific and engineering domains
  - Creative software is beginning to seem inevitable....it's a good time to join
- We have to worry about two main issues
  - Artefact generation and assessment of creativity
- Computational creativity is a sub-area of AI, but it is distinct in many ways
  - There are questions over the value of the Turing test
  - We don't necessarily want reliability, we want surprise and novelty
  - CC software is designed to make people think more, not less
- Has applications to the building of software for ludic purposes
  - Procedural content generation for games, in particular

Further Reading

- AI Bite on computational creativity
  - www.doc.ic.ac.uk/~sgc/papers/colton_aisbq126.pdf
- Wiki Page
  - http://en.wikipedia.org/wiki/Computational_creativity

- AI Magazine Special Issue
  - Especially the editorial and the Veale, Wiggins and Cardoso historical article
  - www.doc.ic.ac.uk/~sgc/papers/colton_aimag09_editorial.pdf

- Our group web pages: ccg.doc.ic.ac.uk

Shameless Plugs

- Forthcoming book on "Creativity and Computers"
  - Worth a read!
- Five year research project on "Computational Creativity Theory"
  - Consider getting involved!