Computer generated car design
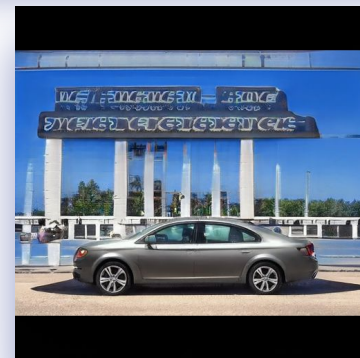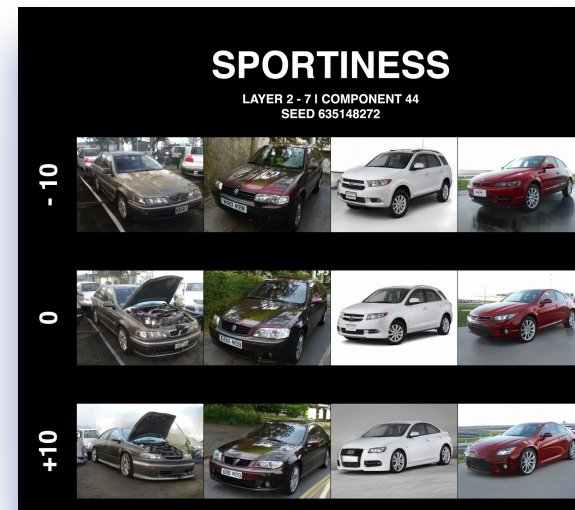
Steps to deeming the system creative by Lennert Bontinck

lennert.bontinck@vub.be | creative-car-design-vub.lennertbontinck.com

Remember my project?

- Pre-trained StyleGAN2 model
  - Create images of cars
- Extended GANSpace tool
  - Have control over the GAN
  - Modify tool for project
- Generative vs creative
  - Situate system in a creative framework
  - Exhaustive discussion on the internal and external evaluation

Bontinck, L. (2021). *Computational creativity project* [GitHub commit: 847d3b5...]. Retrieved May 3th, 2021, from https://github.com/pikawika/VUB-CC-Project

Status update

- Pre-trained StyleGAN2 model ✔️
- Extended GANSpace tool ✔️
- Generative vs creative 🔨
  - Situate system in a creative framework 🤔
  - Exhaustive discussion on the internal and external evaluation 🕐

Choosing the "right" framework

- Not as easy as it seems
- How to build a CS (Ventura, 2017)
  - Generalise CS components to more easily represent CC system
- The CSF (Wiggins, 2006)
  - Formalise concepts of Boden's (2003) philosophical theory of creativity
  - Focus on what programs do
- ...

Boden, M. A. (2003). *Creative mind: Myths and mechanisms(2nd ed.)*. Routledge.
Ventura, D. (2017). *How to build a cc system. ICCC.*
Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19*(7), 449–458. https://doi.org/10.1016/j.knosys.2006.04.009

About Boden's philosophical points

- P(ersonal) vs H(istorical) creativity
  - Historical can't be enforced
  - Non-historical might even be more interesting
- Exploratory vs transformational
  - The generator transforms based on discriminator
  - Latent space exploration

Boden, M. A. (2003). *Creative mind: Myths and mechanisms(2nd ed.)*. Routledge.

Description in the CSF (1)

- The universe (U)
  - Technically: all RGB combination of pixels
  - Generator: all images deemed "real" by the discriminator
  - Thus: images containing cars
- Conceptual space (C)
  - The set of all images the generator can make based on different seeds (noise input) with its latest transformers
- Clearly, $U \subset C$

(a) Traditional   (b) Style-based generator

Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19*(7), 449–458. https://doi.org/10.1016/j.knosys.2006.04.009
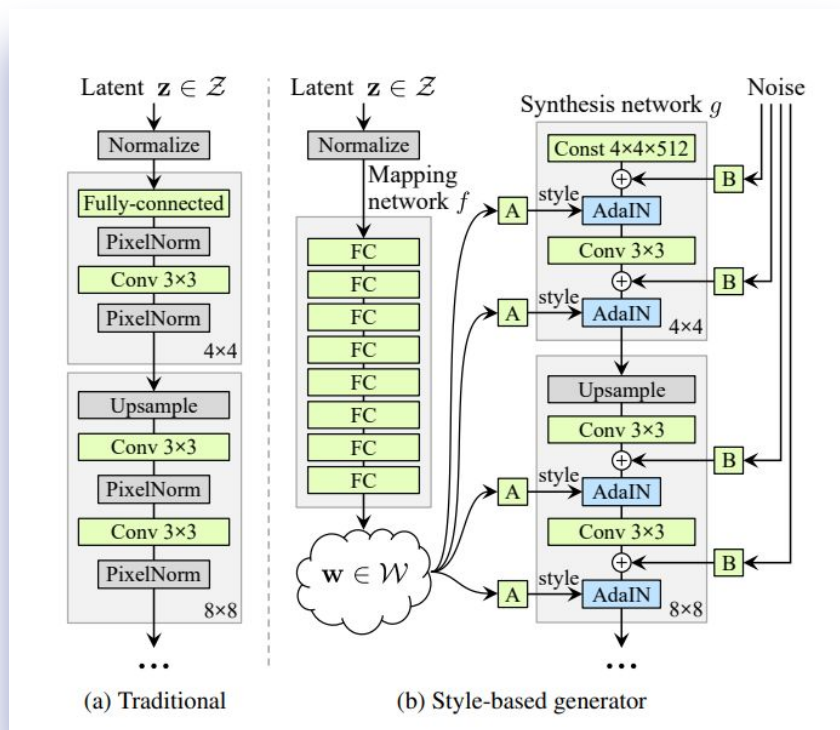
Description in the CSF (2)

- Remember C = [[R]](U)
  - Thus R, the rules constraining the space, are the same rules defining the *state* of the generator
- The rules T
  - Rules that introduce randomness and noise as restrictions on latent spaces
  - GANSpace uses these to "explore the conceptual space"

(a) Traditional   (b) Style-based generator

Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19(7)*, 449–458. https://doi.org/10.1016/j.knosys.2006.04.009
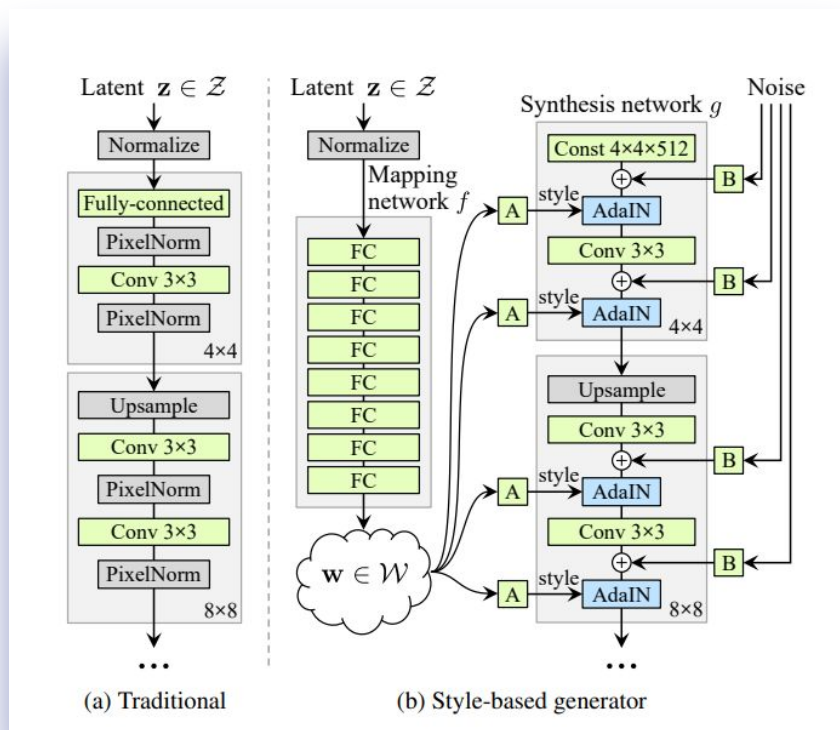
Description in the CSF (3)

- The rules E
  - The rules that define the discriminator can be used to assess the quality of the generator image
  - A similarity checking system can test for P-creativity

(a) Traditional (b) Style-based generator

Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19*(7), 449–458. https://doi.org/10.1016/j.knosys.2006.04.009
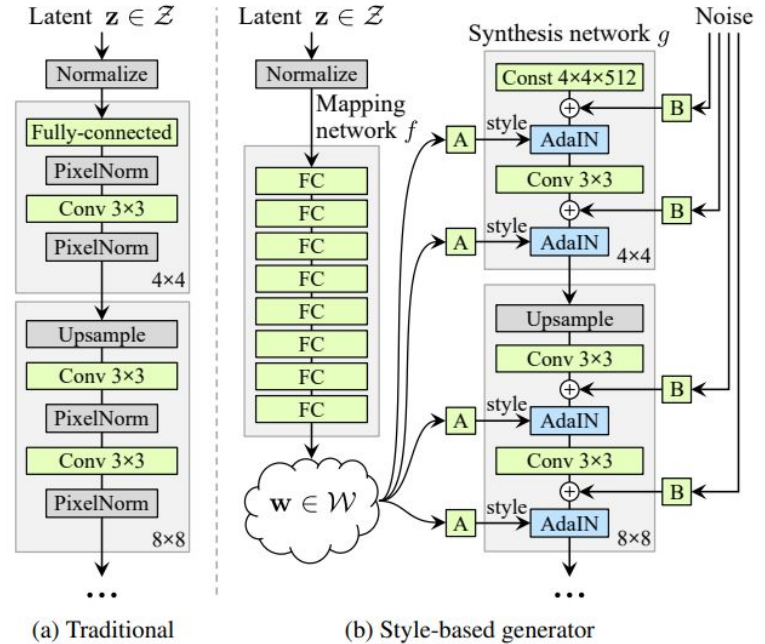
Description in the CSF (4)

- Is the output of $F^\diamond$ infinite?
  - Limited by output of 512x512 images
  - Limited by StyleGAN2 seed limit
  - Limited by GANSpace 512 dimensioned vector for latent space exploration
- Thus: $e_c = <R, T, E>^\diamond(\{T\})$ is also finite
- Note: GANSpace could possibly bypass some of StyleGAN2's rules, making $e_c \not\subseteq C$

Latent $\mathbf{z} \in \mathcal{Z}$

Normalize

Fully-connected

PixelNorm

Conv 3×3

PixelNorm

4×4

Upsample

Conv 3×3

PixelNorm

Conv 3×3

PixelNorm

8×8

...

(a) Traditional

Latent $\mathbf{z} \in \mathcal{Z}$

Normalize

Mapping network f

FC
FC
FC
FC
FC
FC
FC

$\mathbf{w} \in \mathcal{W}$

Synthesis network g Noise

Const 4×4×512

B

style   AdaIN

Conv 3×3

B

style   AdaIN   4×4

Upsample

Conv 3×3

B

style   AdaIN

Conv 3×3

B

style   AdaIN   8×8

...

(b) Style-based generator

Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19*(7), 449–458. https://doi.org/10.1016/j.knosys.2006.04.009

Defending transformational creativity
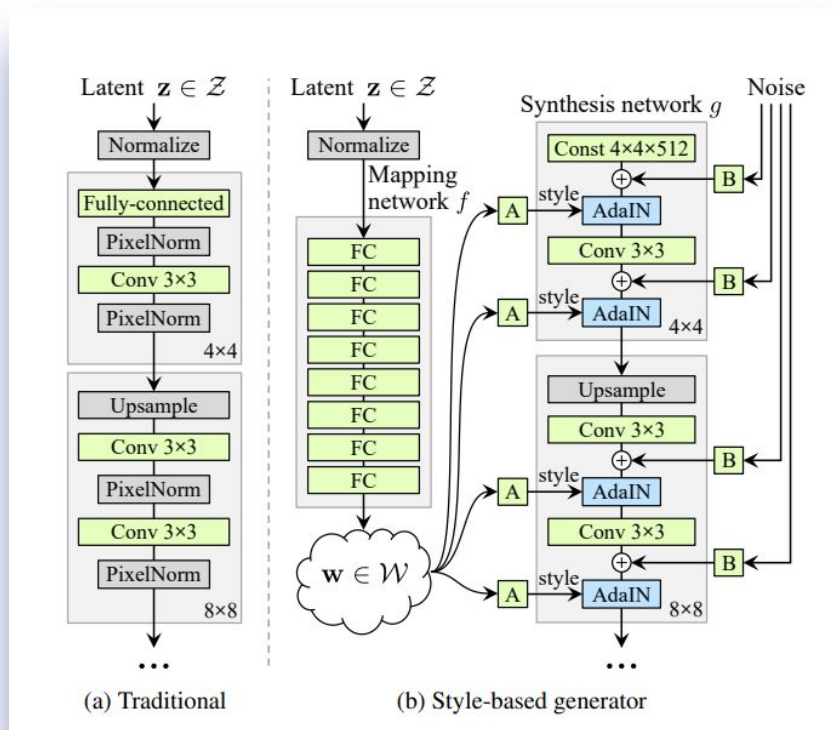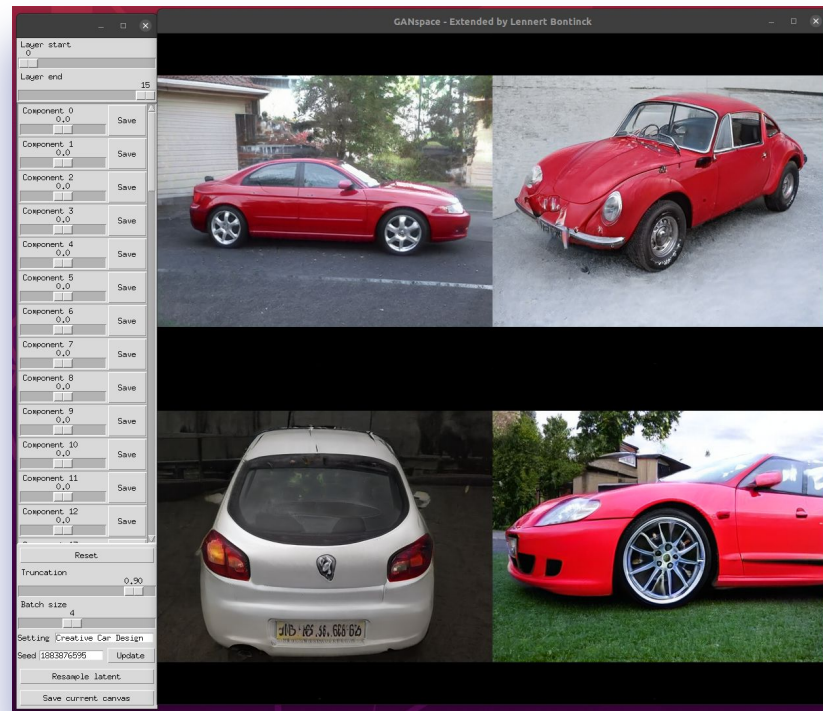
- Remember R: the rules constraining the space, are the same rules defining the *state* of the generator
  - StyleGAN2 changes the rules of the generator based on exploration that yields more output accepted by E, thus while training, R is changed
- GANSpace can (manually) explore T, modification might allow it to transform T, latent space restrictions in particular

Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19*(7), 449–458. https://doi.org/10.1016/j.knosys.2006.04.009

What's next?

- Describe the system using "How to build a CS" (Ventura, 2017)
- "The study and support, through computational means and methods, of behaviour exhibited by natural and artificial systems, which would be deemed creative if exhibited by humans." (Wiggins, 2006)
  - external validation!

You are rating a computer generated car design

Quality	● 1 (-) ● 2 ● 3 ● 4 ● 5 (+) An image is considered of good quality if it doesn't contain graphical glitches or artifacts as explained in the introductory video.
Colors	● 1 (-) ● 2 ● 3 ● 4 ● 5 (+) Colors of an image are considered good if they are viable in real life. Remember, some color combinations may be ugly to you but still realistic. An image has bad colors if it has purple grass, red shadows...
Creativity	● 1 (-) ● 2 ● 3 ● 4 ● 5 (+) Whether you find the image creative is a subjective manner, if you recognize (elements of) existing cars please leave them in the notes section. Remember some of the examples given in the introduction video.
General impression	● 1 (-) ● 2 ● 3 ● 4 ● 5 (+) An overall rating on how pleased you are with this car design. This is subjective, feel free to leave reasoning in the notes.

Bontinck, L. (2021). *Computational creativity project* [GitHub commit: 847d3b5...]. Retrieved May 3th, 2021, from https://github.com/pikawika/VUB-CC-Project
Ventura, D. (2017). *How to build a cc system. ICCC.*
Wiggins, G. A. (2006). A preliminary framework for description, analysis and comparison of creative systems. *Know.-Based Syst., 19*(7), 449–458. https://doi.org/10.1016/j.knosys.2006.04.009

Questions about Computer generated car design?

Steps to deeming the system creative by Lennert Bontinck

lennert.bontinck@vub.be | creative-car-design-vub.lennertbontinck.com