A prática da impressão 3D não é nova, porém ela têm sofrido um advento de popularidade nos ultimos anos, ao que se deve esse boom da impressão 3D?

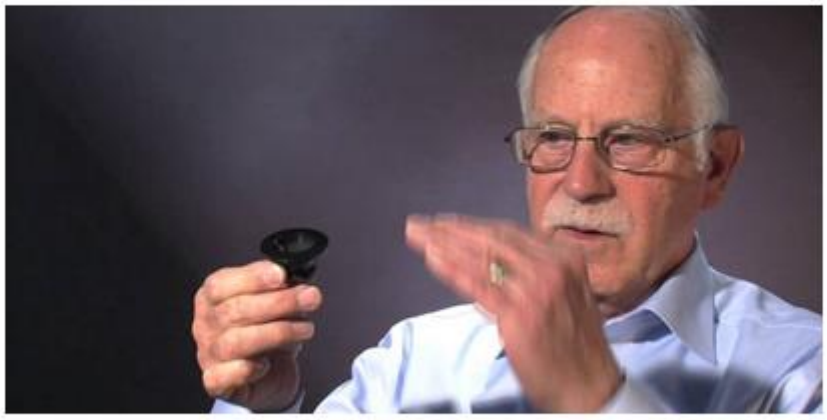
The 3D printing is not new, but it had gainned a popularity advent in the recent years, what caused that boom of 3D printing?

Already in the eighties the first patents were registered in the field of 3D printing. Two important patents in the US were developed from Charles Hull and Scott Crumb. You can also say in a certain way from Steve Jobs and Bill Gates of the 3D printing industry.

The first patent after his patent application received Mr. Charles Hull's (in the US) in the year 1986 for the invention of the Stereolithography Aperatus. The basic principle of this technology is, that a "liquid photopolymer (e.g. an epoxy resin) in a vat is selectively cured by light-activated polymerization to create a 3D object layer by layer based on a digital model". Charles Hull was few years later a co-founder of 3D Systems in the US. His patent expired in 2006 and many other companies such as Formlab (an MIT start-up) followed with this 3D printer technology in the market. The Stereolithography Aperatus from the year 1986 was used for "Rapid Prototyping" to accelerate research and development processes in the industry segment only. Charles Hull is considered today as the father of 3D printing. He has received numerous awards and honors.

⇨ **Consider figure 1**

Figure 1:
Chuck Hull Receives Award From Western Society of Engineers.



1) Source: http://www.3dprintingbusiness.directory/the-world-chuck-hull-receives-award-western-society-engineers/?utm_content=buffer3cc18&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer

Scott Crump received the patent for his "Fused Deposition Modeling" (FDM) 3D printer in 1989 in the USA. In the FDM process (which is also called as FFF – Fused Filament Fabrication), a plastic thread is melted and dispensed through a nozzle or orifice and is distributed layer by layer on a platform to create a 3D object based on a digital model. Scott Crump was few years later a co-founder of Stratasys (in the US), now a globally active company like 3D Systems. In 2009 the patent expired. With the expiry of the patent, the start-up shot for a global boom began: Makerbot and many other 3D printing companies all over the world began to manufacture 3D printers for the makers and home users market (similar to the PC revolution in the eighties). A new scene of makers and home users arose, open market places

with free exchange of 3D models exploded. Only a few years later, around 2012, an explosion followed about 3D printing in the media.

As you noticed, beside “Rapid Prototyping” a new term came up: “3D printing”. The term "3D printing" was already coined at MIT in 1995 when then graduate students Jim Bredt and Tim Anderson modified an inkjet printer to extrude a binding solution onto a bed of powder, rather than ink onto paper. That means with the makers and private users the boom of 3D printing started in 2009. Beside the terms “Rapid Prototyping” and “3D printing” a third term “Additive Manufacturing” is used in the industry. Additive Manufacturing, because the technology is fabricating an object layer by layer based on a digital model. But 3D printing is the most popular term today.

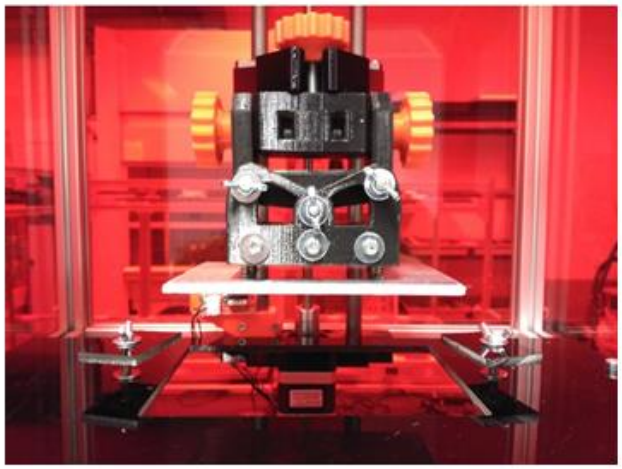
In addition to the historical development of 3D printing, FabLabs (= Fabrication and Laborartories), an initiative from Professor Neil Gershenfeld of MIT in Boston 2002, also led now in 2009 to the arrival of 3D printers (mainly FDM printers because that 3D printers are more easy to learn) in the FabLab. FabLabs are accessible to everyone, to experiment and to produce small series of new products by using 3D printing and other technologies.

Today more than 30 different 3D printing technologies are available. More than 1,000 different materials can be used for 3D printing, e.g.: plastics, plaster, stainless steel, gold, silver, platinum, different metal alloys, ceramics, glas, silicone, different food, different biomaterials, etc.

Now you can buy 3D printers for about 1,000 dollars and Do it yourself sets (“DIY sets”) to construct a 3D printer already start at $ 99 (http://www.101hero.com/pre-order). Beside this you find many open source 3D printers in the internet, e.g. the “RooBee One” SLA/DLP 3D printer in thingiverse (http://www.thingiverse.com/thing:2001118) as well as FDM printers (http://www.thingiverse.com/rasarmg/collections/fdm-printer-design).

⇨ **Consider figure 2**

Figure 2:
The “RooBee One” SLA/DLP open source 3D printer.



1) Source: https://youtu.be/Pl-qfTVvqJ0 & http://www.thingiverse.com/thing:2001118

Martin G. Bernhard

qual o limite da impressão 3D?
What's limit of 3D printing?

Some general limitations of 3D printing are:

The print speed is for most of the 3D printing technologies to slowly:
An important limitation is the print speed, also for large industrial printers, in most of the 3D printing technologies. The printers are too slow to be used in mass production. Only few 3D printing technologies, e.g. contour crafting, are competitive with other manufacturing methods like subtractive or formative manufacturing. One company example of printing buildings is WinSun (China, headquartered in Qingdao). The global market leader is able print a villa with 200 square meters within 24 hours, a cheap low income house (~ 70 square meters) within 12 hours, five five storey houses, freeform houses, office buildings, and a selection of furnitures, etc.

The printer volume size is limited for most of the 3D printing technologies:
Printed objects are limited by the printer volume size. The biggest print room volume size have printers in the construction segment, e.g. WinSun has big halls for pre-fabrication of buildings with a printing volume of about 2.500 cubic meter, but most of the large scale printers have a print room volume of few cubic meters. One example of large scale printers is the BigRap 3D large scale printer. The BigRap GmbH is a start-up from Berlin, Germany, https://bigrep.com. Another example is Local Motors which is using Stratasys 3D printers for mass production of cars. The first 3D printed car (75% of the car components are 3D printed), the LM3D, is offered this year for 53,000 dollars (https://www.youtube.com/watch?v=OaVb3cdv13w). The production facility of Local Motors is using a special 3D printer, a BAAM ("Big Area Additive Manufacturing") printer to print the entire car frame and many other components in one production step. The LM3D consists of round 80 components and parts which means a high reduction of parts in comparison to other cars which consistis of 6,000 to 10,000 parts & components. 3D printing has the advantage, to integrate more functionality into the parts which leads to a high reduction of parts for the final product.

Different colors and materials:
Also printers which are able to print different colors (or different materials) at the same time with different print heats are expensive and not used in the moment for mass production.

Still not enough printable materials available:
Inspite of the fact, that in the meantime more than 1,000 printable materials are available, the range of materials is considered as limited.

Costs for mass customization are partly to high:
3D printing is a preferred technology for mass customization, e.g. eye-glass frames, prosthesis, teeths applications, shoes, etc. But when customization isn't important, 3D printing is in the moment not competitive. For one, printing costs per part are highly sensitive to the utilization of the "build room," the three-dimensional area inside the 3D printer where the laser fuses the metal or plastic powder. Therefore, contract manufacturers that perform 3D printing such as Shapeways generally wait to fill a batch that uses the entire build room. Printing just one part raises unit cost considerably; so economies of scale do matter (https://hbr.org/2015/06/the-limits-of-3d-printing).

Labor costs and costs to develop new skills are underestimated:
The labor and new skill costs are underestimated: Creating printable files involves two steps: creating a 3D model that can be printed, and create the "slicing" (means create the G-Code for the printer) that volume model in the best possible way to avoid material wastage and

prevent printing errors. Both steps require expert knowledge. That means upfront investments to create printable files are necessary. In general the introduction of 3D printing to print parts, components or final products is a reengineering of at least the production processes. New skills must be developed too.

Protection of design and materials:
One huge problem with 3D printing is how to protect designs and materials. Perhaps a designer could supply basic models for free, but charge for customization. Many "Freemenium" market places exists. But the technology itself makes it easier to deconstruct and reproduce products, which makes it harder to control the usage.

Global rules are missing for critical 3D printing application areas:
Beside this the issues of regulation and litigation could slow down the pace of innovation, but it won't stop it. One example is Cambrian Genomic, a very special 3D printing service (US), which is able to print DNA to create new or customized plants, animals, etc. They called in 2015 for a new competition "Create Creatures" with genetic editing tools in the first step, but to print the new DNA out by using Cambrian Genomics. To change DNA and genomes is for sure a very critical issue. Global rules are missing. I personally think, that some countries already compete among each other to create "hybrid beings".

o que é impressão 4D e 5D?
What is 4D and 5D printing?

4D printing is in few words 3D printing plus a transformation formation after the 3D object is printed. The 3D object receives after the print a trigger, e.g. heat, vibration, gravity, electricity or magnetism and than the transformation process of the 3D object is starting to the target 3D object. The precondition is to use "smart and programmable materials". The 3D object can change the shape, the size or / and in the color. Many research institutions are working in the area of smart programmable materials. Imagine if you buy a wooden plate, bring the plate at home and then the wooden plate begins to fold so you get a chair after 30 seconds. But also in the medicine area many applications are conceivable: e.g. print a very thin pin, inject the pin into ear, and then the pin folds into a hearing organ without a difficult sugery.

The term 5D printing is a bit confusion when you think about 4D printing which is connected to smart programmable materials. With 5D printing, or 5-axis printing, the print bed is capable of moving back and forth on 2 axis in addition to the X, Y and Z axis of the 3D printer, hence the total number of 5 axis. This 5D printing technique has been originally pioneered by William Yerazunis, the senior principal research scientist at the Mitsubishi Electric Research Labs. Today 5D printing is mainly used as a connection between (robot arms and 3D printers) e.g. a 6-axis robot and a 3D printer. An inspiring example is the 6-axis KUKA 3D printing robot (https://www.youtube.com/watch?v=K-l2XAkZxVg).

With 5D printing it is possible to place around one production step, e.g. within in a car manufacturing process, numerous 6-axis robots with different technologies to increase the production speed in a single production step.

o que ela podem impactar na vida das pessoas?
How can it impact people's lives?

According a speech from Barack Obama from the year 2013: "3D printing has the potential to revolutionize the way we make almost everything." (http://www.shapeways.com/blog/archives/1921-Why-President-Obama-Mentioned-3D-Printing-in-the-State-of-the-Union-Address.html). For sure 3D printing has changed and will further change in the next years in many area the live of the people, the following few examples are an abstract only, what you can do with a 3D printer at home, e.g.:

- Print own item at home e.g. you can print
  - the toys for your kids,
  - your own artworks like a sculpture
  - for your interior design a vase or lampshade or

- print spare parts at home (e.g. print your plastic mobile phone cover or from Porsche to print wash water pump for the model "Porsche 944" you find it in thingiverse: http://www.thingiverse.com/thing:29641 and can download the spare part and print it out).

- Beside this it is possible to print in the future final products at home, e.g. from Faraday Motion (http://www.faradaymotion.com/hyperboard/) which developed a new mobility product, a "Hyperboard" (3d Printed Electric Skateboard). Means after the payment you can download the files and start printing your own Hyperboard.

- And what you can not print at home, for that you can use a 3D printing service:
  When you search for a special item, you can go to www.shapeways.com to buy "Digitally Hand Crafted" personalized, 3D printed products or create your own product and send it to a 3D printing service and they print it out and send it to you. Shapeways (US) offers more

than 100 different materials and many 3D printing technologies for the 3D printing of their customers.

Beside these few examples many industrial 3D printed applications are already available:

- Another example is that you can buy in 2017 a 3D printed car, the LM3D from Local Motors (USA), as mentioned before. Beside this car Local Motors developed the 3D printed self-driving minibus "Olli". This 3D-printed autonomous vehicle Olli, an all-electric vehicle, is deployed in Berlin, Dubai and many other cities in the US and created a high demand (consider the interview with the owner of local motors: https://www.youtube.com/watch?v=K564rXrlZbc). Companies like Local Motors move now in many cities across the world, where they find high educated people and an appropriate environment. Beside Local Motors more than 25 companies are working to create 3D printed cars as well as self-driving cars, trucks, and busses. Also the bike and motorbike industries are using 3D printing in the meantime for rapid prototyping as well as printing components, e.g. a bike frame (from Empire Cycle).

⇨ **Consider figure 3**

Figure 3:
2016: Olli - Local Motors, Local Motors has built Olli, an all-electric autonomous vehicle.

Source(s): https://localmotors.com/olli/ Martin G. Bernhard

- And here must be mentioned also the aircraft and aerospace industries: Boing and Airbus have many 3D printing projects internally to print aircraft interior equipment as well as aircraft components. 3D printed aircraft components are: nosecone, wings, blades, variable geometry parts, honeycombs, coverings, bearing housing, slices, rings, blisk (Scooter discs and shovels) as well as frame parts.

  In June 2016 the world's first 3D-printed aircraft touches down as aviation industry embraces green benefits. Dwarfed by huge jets all around, the driverless mini-plane "Thor" was nonetheless an eye-catcher at the Berlin air show. The small Airbus marvel is the world's first 3D-printed aircraft.

➔ **Consider figure 4:**

Figure 4:
2016: Windowless, weighing in at just 21kg and less than four metres long, the drone "Thor" – short for "Test of High-tech Objectives in Reality" – resembles a large, white model aeroplane.

Source(s): http://www.scmp.com/news/world/europe/article/1955806/listen-your-soon-saab-bell-worlds-first-3d-printed-aircraft-touches

rtin G. Bernhard

- Beside the high-end area of aircrafts many 3D printing applications are already available in the space industry, e.g. print parts and components for satellites, rockets, propulsion systems, Boing just announced in Februar 2017 to print 600 parts for the "Space Taxi", etc. Beside this activities mentioned above 3D printers exist already for different space and spaceship applications, examples are:
  - for the application of 3D printing in the ISS, the AMF – Additive Manufacturing Facility (UK) is able to print in a zero gravity environment.
  - Robot arms with 3D printers for outside maintenance work of the ISS.
  - a printer usable on asteriods from "Planetary Ressource" in collaboration with Stratasys for the process of asteroid mining. The idea behind is to fabricate not on the earth, but on an asteroid, where the metal is directly available and save money with the reduced weight of rocket.

- Further industrial 3D printing areas are toys (e.g. Mattel, US), furnitures (e.g. Fleximatter, Israel), jewleries (e.g. Stilnest, Germany), shoes (e.g.Feetz, US), sport shoes (e.g. Addidas, Germany) handbags (e.g. the monkey bag from Kipling, Netherlands), dresses and interior design (e.g. Nerveos Systems, US), eyeglassframes (e.g. Framepunk, Germany), music instruments (e.g. the open source violin from Hovalin: www.hovalin.com/ and please hear the sound of the violin: https://youtu.be/9fZ_vYkuuZU), etc.

- I avoid here to describe 3D printing applications in the military area.

- Areas like medicine, health, construction, and food are described in the next chapters.

The industrial area goes clear into the direction of 5D printing (robot arms combined with 3D printers) as well as Big Areas Additive Manufacturing ("BAAM") systems combined with other manufacturing systems with the goal, to reduce the entire human work to zero in production processes.

But when most of the humans are not any more working because of automatization and using artificial intelligence ("AI") for the guidance of tasks and also guidance of companies (e.g. the world larges hedge fund company, Bridgewater Associates, is replacing top managers against AI), what is the answer? In the moment two possible concepts are discussed:

First concept: The taxation of robots (proposed also by Bill Gates) is a must and

Second concept: Provide a basic income without any precondition (pilot projects are running already in Europe) so that the products have also customers in the future which are able to buy the products (proposed also by Elon Musk).

These concepts sounds great and also convenient for the mankind, like in a science fiction. But we will see what will happen in the future….

Na área da saúde onde a impressão 3D já ajuda em tratamentos e até onde ela poderá contribuír com o avanço da ciência?

In the health area, where is 3D printing already helping treatments? And how far can it contribute to the advancement of science?

We, ECG Management Consulting GmbH (Germany) means my colleagues and myself, developed together with a client in Germany over a period of three years a global catalog with practical 3D printing applications and running research projects in the area of medicine and bioprinting. In the meantime several hundred applications are available in different countries. Most of the countries with an own legal system (e.g. FDA in US) to allow the 3D printed application for medical purposes.

In the medicine area a selection of few examples are

- 3D printed anatomic objects for education purposes (consider e.g. www.3danatomyseries.com/, Germany)
- 3D printed organ models for sugery planning (e.g. the 3D printing service WhiteCloud, US)
- 3D printed prosthesis for different purposes:
  - hands and arms (e.g. Open Bionics, UK)
  - exoskeletons (e.g. 3D Systems as well as JAECO Orthopaedic and Stratasys produce a WREX (Wilmington robotic exoskeleton arm)
  - wheelchairs (e.g. Benjamin Hubert, London)
- Implants, e.g. for knee-replacements (e.g. ConforMIS)
- Customized casts insteed of using plaster, e.g. www.evilldesign.com/cortex (and consider the video: https://youtu.be/WBRuOTCPGjM).
- A mouthguard for aiding sleep apnoea sufferers (Oventus, Australia)
- Dental industry, e.g. crowns, bridges, jaws, theets, e.g.
  - EnvisionTec, US and Germany
  - Javelin Technologies (partner: Stratasys), Canada

Bioprinting, mainly in the science and research pipeline:

- Tissue engineering, e.g. print skin (e.g. OrgaNovo (US) to print skin for testing purposes for medicals and cosmetics. But for sure also to implant in few years 3D printed skin.
- Tissue engineering to print organs, e.g. a kidney, liver, heard, and other organs are in the research pipeline. Beside this it happened in Harvard in announced in Oct. 2016, Harvard University researchers have made the first entirely 3D-printed organ-on-a-chip with integrated sensing. Built by a fully automated, digital manufacturing procedure, the 3D-printed heart-on-a-chip can be quickly fabricated and customized, allowing researchers to easily collect reliable data for short-term and long-term studies.
- An important practical application is the replacement of blood vessels: e.g. the Revotek 3D blood vessel printer, made in China. Because of high demand in China difficult to buy from other other countries.

Beside this many applications are in the science and research pipeline, also in the 4D printing area.

Because of the 3D and 4D printing applications in medicine as well in bioprinting I personally have the hope of improvements and a much broader medical help especially for poor people in many countries. I highly recommend the enablingfuture.org (please consider: http://enablingthefuture.org/ as well as the e-nable community). E-nable - A Global Network of passionate volunteers using 3D printing to give the world a "Helping Hand." E-nable already helped until end of 2015 more than 1,800 people across the globe, people which needs help. The world wide community of more than 7,000 volunteers with access to 3D hand models helps, prints and donate prothestic hands.

o que a impressão 3d pode impactar o futuro da humanidade em termos de alimentação e construção civil?

Can the 3D printing impact the future of humanity in terms of food and construction?

Customer segments of 3D printed foods are:

Yes, both areas are mature developed. I start with the construction area:

In the construction area I mentioned already WinSun from China. China is the dominating country for 3D printing in the construction segment. Beside WinSun in China another important company is the Zhuoda Group. Both companies are construction companies and have not the interest to sell 3D printers for construction. They use the 3D printer to realize the competitive advantage. They cover a broad range of different building types like:
- low income houses,
- villas,
- five level apartment houses,
- freeform houses, etc.

In August 2016 WinSun signed a contract in Saudia Arabia to print 1.5 million buildings within the next years (to surpass the gap of missing homes in that region), which is largest-scale 3D printed construction project in history.

The great inventor behind this technology is likely to be Prof. Dr. Behrokh Khoshnevis's from the University of Southern California with his "Contour Crafting" invention. "Contour Crafting is a fabrication process by which large-scale parts can be fabricated quickly in a layer-by-layer fashion. The chief advantages of the Contour Crafting process over existing technologies are the superior surface finish that is realized and the greatly enhanced speed of fabrication … the future development direction of contour crafting, a relatively large multidisciplinary research team at the University of Southern California will be investigating the application of the technology in construction of modern civil structures, construction of structures on the moon and Mars, and in fine arts on the creation of large ceramic sculptures." (http://www.contourcrafting.org/). But also the University of Western California does not sell printers!

- ⇨ **Consider figure 5:**

Figure 5:
The printer behind "Contour Crafting".

Source(s): http://www.contourcrafting.org rtin G. Bernhard

But it is possible to buy 3D printers for construction for example from Apis Cor (Russia). These are mobile printers for transport with a weight of 2.5 tons and five meters wide. The construction speed or print output per day amounts 100 м² (http://www.apis-cor.com/). But there is one important open question and that is the material mix needed for construction purposes. It is possible to buy the secret construction material mix or to sign a licence agreement.

The other huge segment is food. Food can have suddenly a design to make it delicious. Food can be customized for certain target groups, e.g.
- home user – to deliver them via the computer new recipes for the next day and control much more the food supply chain.
- restaurants (just in 2016 in London opened the first food restaurant with 3D printed meal, "The Ink")
- patients in hospitals,
- customers in the airplane,
- soldiers in the military area,
- astronauts do deliver appropriate food with vitamins for their mission,
- solve the world hunger and sustainable food
- etc.

A long list of companies from different areas (food industry, 3D printer manufacturer, and new market entrants) are working to manufacture food printers.

What benefits could 3D printed foods provide?

- The need for packaged foods that contain additives, preservatives and unbalanced amounts of sugar and salt can be reduced by using 3D printed foods.
- Fresh, more nutritious meals can be prepared in much shorter time with 3D printers than by traditional or commercial methods.
- Because 3D printers can be connected to the internet, food can be prepared by issuing remote commands.
- 3D printed foods can be shaped into forms that are aesthetically pleasing.
- Old people and people struggling with cerebral palsy or stroke who have difficulty with chewing and swallowing, will have access to a large variety of 3D printed foods.

- Instead of relying solely on freeze-dried foods in space, astronauts will have access to 3D printed foods.
- As the cost of 3D printing continues to come down, individual families and institutions such as schools, hospitals, the military and similar institutions will be able to provide large scale nutritious and cost effective meals at reduced cost.
- The burden of cooking for a large family will be eased by utilizing both 3D-printed foods and traditional cooking.

However, there are obstacles to overcome before 3D printed foods become common' (https://www.indiacadworks.com/blog/3d-printed-foods-become-common/).

- Because food is printed in layers, it will take clever engineering to make printed food look and feel like traditionally prepared food.
- Cleaning of the printer should be easy and efficient. Food particles should not migrate to parts of the printer where decay and bacterial growth would happen.
- It will be a challenge for 3D printed food to match the texture and taste of traditionally prepared food.

All the mentioned above areas are running already or are in a project phase.

A categorization and selection of food printers you find in the following four figures:

⇨ **Consider the following figures 1, 2, 3, 4**

Figure 6:
Food can have a design, e.g. the castle "Neuschwarnstein" made of marcipan.

Source(s)(n http://www.print2taste.de/de/druckbare-lebensmittel/

Figure 7:
Categorization of food printers

Allround food printer
- Bocusini / Print2Taste
- Natural systems / Foodini
- XYZ Systems
- etc.

Specialised food printer:
- Chocobot, Choc Creator 2.0,
- Hershey's CocoJet,
- Choctory 3D printer
- Katje's Magic Candy Factory-The world's first Wine Gum 3D printer
- Etc.

Source(s): Martin G. Bernhard

rtin G. Bernhard

Figure 8:
The Print2Taste is able to print many different food: Jelly, chocolate, marzipan, biscuits, potatoes, crispy pastries, meringues, fresh cheese, butter, mashed potatoes, pea puree, various fruit pies, sausage, liverpaté, ..

- Recipes, videos and ideas can be found at www.bocusini.com

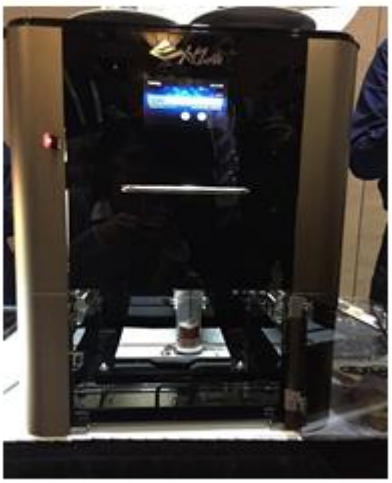
➔ Video:
Food Printer Kickstarter Success: ALL3DP interviews Print2Taste about Bocusini
https://www.youtube.com/watch?v=dT-6BIgxuf0

Source(s): http://www.print2taste.de/de/druckbare-lebensmittel/

Martin G. Bernhard

Figure 9:
3D Food Printers by XYZPrinting. Different models till the alrounder.

Price range from $500 to $2,000
➔ https://www.youtube.com/watch?v=MGxr3boylus.



Tawainese 3D printing company XYZPrinting

FDM 3D food printer.

Printable food: Cookies, pizza, toast, cake,

The prices will range from roughly $500 for the most basic model, to $4,000 for the all-in-one pro.

Source(s) in http://www.3dera.org/articles/20151102-3dera-monday-warm-up-the-top-3d-food-printers-that-will-feed-the-future.html

Today more than 20 food printers are in the market, but mostly used by enthusiasts and specific customer groups mentioned before.

Beside the food printers the meat production will change. Beside cloning techniques also 3D printing of meat is in the pipeline. The US company Modern Meadow has the believe:

"..in a future where animal products are animal-free".

To give some perspective, Mr. Forgacs (CEO from Modern Meadow) talked about what resources it takes to produce one quarter pounder hamburger steak:

- 6.7 lbs grain and forage
- 600 gal. water for drinking and irrigating
- 75 sqft land for grazing and growing feed
- 1,036 BTUs of energy for feed production and transportation
- 13.4 lbs CO2 equivalent release (same as driving your car 25 miles)

So, if we multiply this by a 1000 it's the average carbon footprint of an American per year. Scaling this up, there are 7 billion people walking on earth today. Their meat consumption is currently supported by 60 million land animals. By 2050, the same figures are estimated to be at 9 billion people supported by 80 to 100 million land animals.

Modern Meadow´s core process for meat production will use selected muscle cells, so-called "myosatellite cells", from e.g. porks and add to the cells an animal free growth serum to multiply the cells. To be able to multiply the cells is one reason to use "myosatellite cells". Than they print sheets from cell paste by using a bioprinter. The next step is to assemble the sheets into a meat cube culture and condition the cube to improve the texture. Thausend of muscle strips will mixed to a receive a larger meat mass and combine it with flavor iron and vitamins to create in the last step, to produce the meat in form of sausages etc. This process must be developed to a large-scale production process (which needs time). This process will be more environmental friendly in comparison to the existing meat production. It is fore sure beside the existing meat production and cloning animals an additional future technology to cover the demand of meat in the future.

Sources:

www.modernmeadow.com
https://3dprintingindustry.com/news/update-andreas-forgacs-on-3d-printed-meat-6610/
http://blog.drupa.com/how-3d-printing-can-save-the-environment/

Quais os projetos mais avançados que já existem no Brasil em termos de impressão 3D e o que falta para o Brasil de tornar referência no setor?

What are the most advanced projects that already exist in Brazil in terms of 3D printing?

Initially, the seed was placed within in the last 3 years for start-up companies in e.g. in Belo Horizonte and other regions of Brazil. In Belo Horizonte in the downtown area "104" is an innovation space for start-up companies from Brasil and also a place for start up companies from foreign countries. This place is a very important project realized from the Government of Minas Gerais. This place is a seed place for innovation and also for the innovative start-up companies using 3D printing.

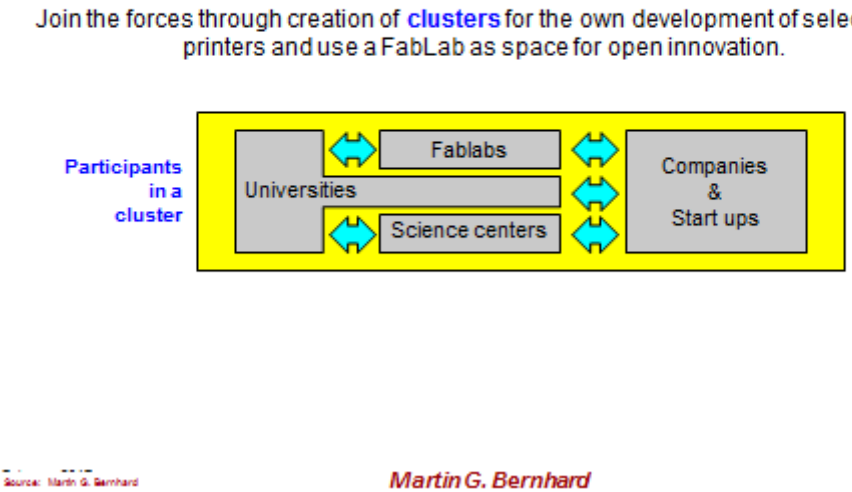
The construction of FabLabs as an important interface between Universities, research centers, companies, start-ups, makers, and also visitors and can be considered as an innovation space for all participants.

FabLabs are already took place in many districts and cities of Brazil. FabLab examples in Brazil are:

- Minas Gerais: The Fab LAB Newton (https://www.fablabs.io/fablabnewton) in Belo Horizonte.
- Minas Gerais: In the State University of Montes Claros ("UniMontes") a FabLab is in the planning process.
- The Garagem Fab Lab in Sao Paulo (www.garagemfablab.com.br)
- The Brasilia Fab Lab (www.brasiliafablab.com.br/)
- The SENAI Fab Lab (https://www.fablabs.io/senaifablab) in the area of Rio de Janeiro. This Lab is the Pilot for a huge program that will be ploting Labs around Rio de Janeiro State, starting inside The Automation and Simulation Technology Center than going for others 40 schools. The principal node is fabrication surrounding 3D printing, Laser cutter, textile área, eletronic and robotics skills, automation, mechanical fabrication, simulation, virtual reality and others fields.

⇨ **Consider figure 10.**

Figure 10:
The FabLab is an innovation space, an interface between Universities and companies and an element of an innovation cluster.



Beside FabLabs also many 3D printing services are available across Brazil. Beside 3D printing services another service, 3D hub (https://www.3dhubs.com/3dprint/Brazil) as a global network of 3D printer and 3D equipment owners is accessable for everyone. With 3D hub you have access to more than 25.000 3D printers worldwide. You can connect your 3D printer also into 3D hub and can start your own business. You can type your needs into the network and find a 3D printer and offer perhaps in your neighbourhood.

Many companies already started to work in the 3D printing area as pioneers. Examples are:

- Minas Gerais, medicine, hand prosthesis: 3D Lopes foundet by Daniel Lopes. Daniel Lopes and his partners delivered till today many hand prosthesis
  Criança de 11 anos recebe prótese feita em impressora 3D.
  https://www.youtube.com/watch?v=ym9o4sAjVyY

⇨ **Consider figure 11.**

Figure 11:
Jan. 31, 2017: O pequeno Matheus de apenas 11 anos, recebeu nesta sexta feira, (27), uma prótese inteiramente produzida em uma impressora 3D

Source(s): https://www.facebook.com/3DLopes/
https://www.youtube.com/watch?v=ymkota-dVuY

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- Sao Paulo, medicine, arm prosthesis:
  The entreprenieur and engineer Thiago Jucá delivers arm prosthesis by using FDM printers. The prosthesis material is an ABS plastic.
  https://economia.uol.com.br/empreendedorismo/noticias/redacao/2017/02/21/ele-faz-protese-barata-de-homem-de-ferro-e-barbie-para-criancas-sem-braco.htm

  Arm and hand prosthesis can be produced with 3D printing much cheaper.

- In the medical field also materialize is working, a 3D printing service headquartered in Netherlands. They took in 2016 the initiative to start a lecture series in Brazil entitled: "Innovation in 3D technology for health". The aim of the lectures is to create awareness about the possibilities of 3D Printing for healthcare professionals, and how our technology can help hospitals treat their patients more effectively. The lectures, attended by over 300 academics, operators and hospital staff, took place at three different universities throughout the country (http://hospital.materialise.com/blog/brazil-3d/).

- And for sure also 3D printer manufacturers are now available in Brazil with FDM and SLA 3D printers, e.g.
  - Cliever Tecnologia
    - e.g. Cliever CL-1, CL1 Black, CL2 Pro Plus (FDM)
    - e.g. SL 1 (Stereolithography)

  - Metamáquina, e.g. Metamáquina 2 (FDM)

  - UP!3d: e.g. UP Plus 2 (FDM)

- The access to other 3D printing technologies is possible through
  - 3D Systems acquired Robtec in Sao Paulo in the year 2014. Robtec is the largest Latin-American additive manufacturing service bureau and the leading 3D printing and scanning products distributor in the region (consider: https://www.3dsystems.com/press-releases/3d-systems-acquire-robtec)

  - Stratasys is located in Santo Andre: Stratasys Direct Manufacturing's Santo André facility

serves the expanding demand in South America (https://www.stratasysdirect.com/contact/santo-andre-brazil/).

According an actual market survey the Brazil 3D printing market will achieve $ 400 Million by 2021 (Source: TechSci Research Report: https://www.techsciresearch.com/report/brazil-3d-printing-market-by-printer-type-personal-3d-printer-vs-industrial-3d-printer-by-maintenance-service-system-maintenance-contract-training-etc-by-material-plastics-metal-etc-competition-forecast-opportunities/866.html).

What is missing for Brazil to become a reference in that sector?

Brazil must improve innovation, number of innovative patens, and the education systems in all areas. Innovation is a commercialized invention, i.e. not just an idea, but an invention must ultimately lead to a sustainable business and new jobs in a company or also a research organization (for example, with a start-up or new business unit in a company). Many Universities e.g. Harvard are receiving with patents a lot of many to finance research projects.

Why are innovation and patents are so important?

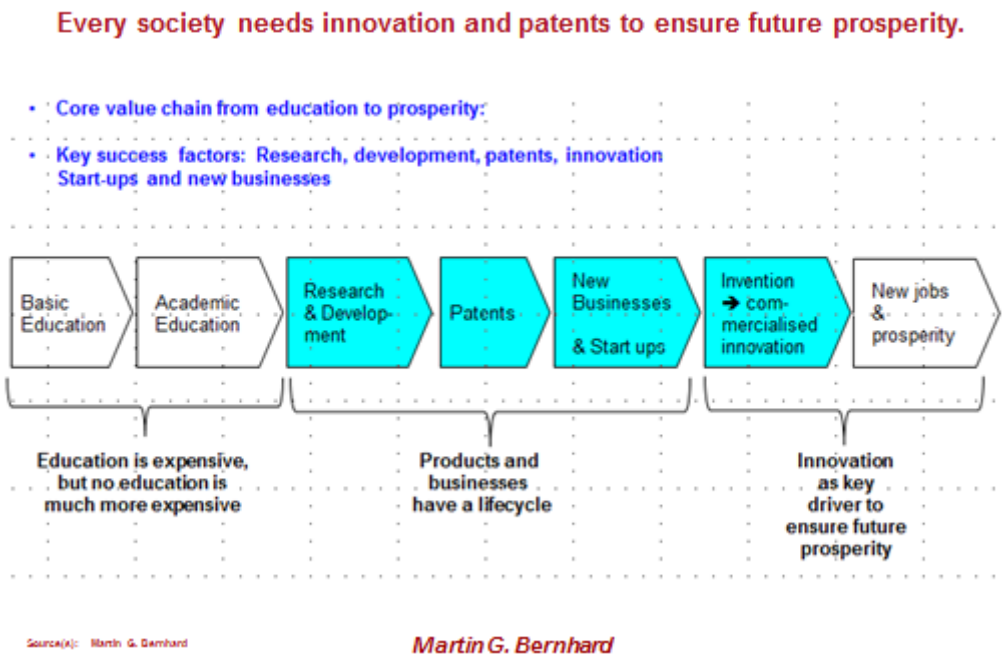
➔Each product has a limited life cycle (e.g. from the mobile phone to the smartphone).

➔Each business model has a limited life cycle (e.g from retail shop in your neighbourhood to internet shops and dealers like Alibaba and Amazon).

➔ Innovation ensures future jobs and future prosperity in a society.

➔ Innovation and the resulting patents ensure markets for a long period for the patent holders. The number of patents can be considered as an assessment measure for an education system of a society. Innovation and patents determining also the competitiveness of a country.

The general process from education to prosperity is shown in the following **figure 12**:



Brazil has today an academic ratio of about 4,5 %, i.e. 4,5 % of the kids in the elementary school receives later an academic degree. Germany for example has 27 %. Many other countries in Europe with more than 30 % have a higher academic ratio like Germany. Finally the academic ratio must be must continually increase.

Furthermore the interface between universities and companies must be improved. For example at least 50 % of all student master thesis should be a collaboration between universities and companies. It is an advantage of both sides, universities and companies, to use such a thesis for practical examples.

Beside these points, the number of innovative patents in Brazil must be increased. According the
"Relatório DE Ciência da unesco (Fonte: Publicado em 2015 pela Organização das Nações Unidas para a Educação, a Ciência e a Cultura, 7, place de Fontenoy, 75352 Paris 07 SP, France, e a Representação da UNESCO no Brasil) pagina 52)" the innovative patent situation is as follow in the time frame from 2009 and 2013:

- ⇨ United States: 110.681 innovative patents
- ⇨ Japan: 45.810 innovative patents
- ⇨ Germany: 12.523 innovative patents
- ⇨ Brazil: 189 innovative patents

This numbers must be continuously improved.

When the academic ratio increase and also the innovative patents, the number of start-ups will increase too. But also an additional push is needed to create a real innovation culture.

For an innovation culture 10 preconditions are necessary:

1. Sponsorship on a government level as well as an innovation system (on the federal country level) with a yearly report from leading innovation professors.

2. Enough well educated talents from many countries: we live in a global fight for the talents!
   ➔ Education system with well educated young people and high academic ratio as well as young people from foreign countries.

3. Establishment of a new company within 48 hours (all legal documents, open bank account, office space).

4. Start ups have no bureaucratic duties within the first 2 years (up to 5 years) and a simple tax system.

5. Good framework and conditions for risk capital and growth capital.

6. Positive basic mood through a very helpful government administration.

7. High speed internet in relevant regions.

8. Foreign peoples with the intension to establish a business or help as an investor for businesses should receive a green card (< 5 years).

9. Access to business angels & experienced professionals.

10. Relevant clusters (science, universities, companies, and Fablabs) are accessible.

Beside the mentioned points above, innovation must be a process and important role in almost all companies in Brazil. Imagine, the construction companies in Brazil will not integrate 3D printing to construct buildings in Brazil. For me is not the question whether construction companies with 3D printing technology will enter the market in Brazil. It is only the question when foreign construction companies will enter the market in Brazil. The construction companies in Brazil should be prepared.

Brazil has an advantage in comparison to many countries in Europe. The average age of the people in Brazil is round 30 and the baby ratio per women is close to 2 (which is healthy). In Europe, e.g. in Germany, the average age is a bit higher than 44 and the baby ratio per women is a bit less than 1,5!

That means Brazil can master the future with many effords and hard work. I am looking forward.

Thank you for the interview.

Belo Horizonte, February 22, 2017

Prof. Martin G. Bernhard
Dipl.-Ing. (Wirtschaftsing.), M.B.A.

in case of questions: mg.bernhard@gmail.com