

## The Impact of Emerging Technology for “Industry 4.0” in Egyptian Packaging Industry

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### Abstract

As a new industrial revolution, the term Industry 4.0 is one of the most popular topics among industry and academia in the world.

Emerging Technologies are realized by the combination with adaptive robotics, augmented reality, cloud computing, artificial intelligence, additive manufacturing, and the Internet of Things (IOT).

In these papers I will discuss and analyze the global packaging trends in light of “Industry 4.0” and the impact and use of the Egyptian market for these emerging technologies. The research problem is summarized in answering how to benefit from the techniques of the fourth industrial revolution in the Egyptian packaging market? And to identify the role of artificial intelligence in implementing the tasks of designing structural and creative packaging. The research aims to shed light on modern technologies of the fourth industrial revolution and their impact on the workflow of packaging design and determine the limits and capabilities of industrial intelligence during the various stages of work in packaging design. The researcher used the descriptive analytical approach to Global packaging trends in light of the fourth industrial revolution, and the experimental approach to the impact of artificial intelligence as one of the tools of the fourth industrial revolution on the packaging designer and a special questionnaire on the extent to which Egyptian packaging institutions use the techniques of the industrial revolution Fourth.

### Results

- 1- Non-Integrated Use of Industry 4 Technologies in the Field of Packaging in the Egyptian Market.
- 2- The Use of Artificial Intelligence and Computer-Aided Design is One of the Most Used Techniques for the Fourth Industrial Revolution in Egyptian Packaging Institutions.
- 3- Industry 4.0 Technologies Improve, Empower, and Expand One Another, It Is a Central Reconfiguration of Work in the Digital Era.
- 4- The Augmented Reality Packaging Serves as a Marketing Tool for Brands and Allows Them to Include a Virtual Element to Their Packaging.
- 5- AI's Power Lies in Its Speed to Rapidly Analyze Large Amounts of Data and Output Alternative Designs, These Can Then Be Reviewed by Designers to Select and Improve the Generated Images, This Increases Speed, Reduces Costs, Improves Efficiency and Creates Multiple Designs.
- 6- Machines Have the Ability to Think but Whether Machines Are Not Creative as People, Creativity Requires Both Originality and Effectiveness, So That Each Designer Has Unique Solutions to Design Problems but Artificial Agent Able to Create Design but It Must Conform to a Set of Constraints.

**Key words:**

(Artificial Intelligence- Augmented Reality- Internet of Things (IOT)- Smart Packaging – Industry 4.0 - PackML).

**ملخص البحث**

يعد مصطلح الصناعة 4.0 باعتباره ثورة صناعية رابعة أحد الموضوعات الأكثر شعبية بين الصناعة والأوساط الأكاديمية في العالم حيث تتحقق التقنيات الناشئة من خلال الجمع بين الذكاء الاصطناعي والحوسبة السحابية والروبوتات الذكية والواقع المعزز والتصنيع المضاف وإنترنت الأشياء، في هذه البحث سيتم مناقشة وتحليل الاتجاهات العالمية للتغليف في ضوء الثورة الصناعية الرابعة وتقنياتها وتأثير واستخدام السوق المصري لهذه التقنيات الناشئة، تتلخص مشكلة البحث في الإجابة عن كيفية الاستفادة من تقنيات الثورة الصناعية الرابعة في سوق التغليف المصري؟ والتعرف على ودور الذكاء الصناعي في تنفيذ مهام تصميم التغليف البنائي والابداعي، ويهدف البحث إلى تسليط الضوء على التقنيات الحديثة للثورة الصناعية الرابعة وتأثيرها على سير عمل تصميم التغليف وتحديد حدود وقدرات الذكاء الصناعي خلال مختلف مراحل العمل في تصميم التغليف، استخدم الباحث المنهج الوصفي التحليلي لاتجاهات التعبئة العالمية في ضوء الثورة الصناعية الرابعة والمنهج التجريبي العملي لتأثير الذكاء الاصطناعي كأحد أدوات الثورة الصناعية الرابعة على مصمم التعبئة والتغليف واستبيان للتعرف على مدى استخدام مؤسسات التغليف المصرية لتقنيات الثورة الصناعية الرابعة

**نتائج البحث**

- 1- يوجد استخدام غير متكامل لتقنيات الثورة الصناعية الرابعة بمؤسسات التعبئة والتغليف المصرية.
- 2- يعد استخدام الذكاء الاصطناعي والتصميم بمساعدة الحاسوب من أكثر التقنيات المستخدمة للثورة الصناعية الرابعة في مؤسسات التعبئة والتغليف المصرية.
- 3- تقنيات الثورة الصناعية الرابعة تعزز وتمكن وتزيد من بعضها البعض، وهي إعادة تشكيل أساسية للعمل في العصر الرقمي لاسيما في مجال التغليف.
- 4- تعمل تقنية الواقع المعزز في التغليف كأداة تسويقية للعلامات التجارية وتسمح لها بتضمين عناصر افتراضية في عبواتها.
- 5- تكمن قوة الذكاء الاصطناعي في سرعته في التحليل السريع لكميات كبيرة من البيانات وإخراج تصميمات بديلة، ويمكن للمصممين بعد ذلك مراجعتها لتحديد وتحسين الصور التي تم إنشاؤها، وهذا يزيد من السرعة ويقلل التكاليف ويحسن الكفاءة ويخلق تصميمات متعددة.
- 6- على الرغم من أن الآلات لديها القدرة على التفكير الا انها ليست إبداعية كالأشخاص، الإبداع يتطلب كلا من الأصالة والفعالية، بحيث يكون لكل مصمم حلول فريدة لمشكلات التصميم فعلى الرغم من قدرة الذكاء الصناعي على إنشاء التصميم المرئي الا انه يجب ان يتوافق مع مجموعة محددة من القيود

**الكلمات الرئيسية:**

(الذكاء الاصطناعي - الواقع المعزز - إنترنت الأشياء - التغليف الذكي – الثورة الصناعية الرابعة – لغة ماكينات التغليف).

**Research Problem:**

The research problem is summarized in answering the following questions:

- 1.How to benefit from Emerging Technologies for Industry 4.0 in the Egyptian packaging market?
- 2.Is Artificial Intelligence Capable to Implement Creative and Structure Packaging Design Tasks?

**Reasons for choosing the research problem:**

- 1.The Result of an Initial Study on the Egyptian Packaging Market in Using Emerging Technology for “Industry 4.0” Which Will Be Explained Later in the Research Papers.
- 2.Industry 4.0 Holds the Key to Accessing Real-Time Results and Data That Will Catapult the Packaging Industry into New Levels of Achievements.

**Research Aim:**

The research aims to Spotlight on modern technologies for the Fourth Industrial Revolution and their impact on Egyptian Packaging Industry workflow and define the limits, and capabilities of industrial intelligence during the various Packaging design stages.

**1- Introduction**

Fusing differing ideas like artificial intelligence, the Internet of Things (IOT), Augmented Reality, and Cloud computing, its goal is to New Industrial Revolution.

How to Embrace These Ideas More Productively into the Packaging Industry Remains a Challenge, However?

The packaging industry also offers numerous opportunities to drive digital change by Using the tool of industry 4.0.

The future lies in smart packaging, Design with (AI) Systems, Add value by Augmented reality and fully automated packaging lines, and digital value chains.

Those Packaging companies that invest in a corresponding competence development can generate a decisive competitive advantage.

**2- An initial study**

My search started with an initial study presented here which aimed to know the current state of the Egyptian packaging market towards industry 4.0 technologies through answering the following Questionnaire as shown in the table number (1) by 20 companies and institutions in the field of packaging.

**2-1- Research limits**

**Thematic limits:** the current state of the Egyptian packaging market towards industry 4.0 technologies.

**2-2- The Research Population**

The study sample was chosen according to the standard of specialization and experience in the field of packaging printing.

**2-2-1.** A survey of the printing enterprises in the field of packaging was conducted during (Print 2 Pack 2019) Exhibition Which includes the largest packaging institutions in the Egyptian market.

2-2-2). 25 institutions working in the field of packaging printing in the Egyptian market were identified, and the questionnaire was conducted through a personal interview with representatives of the printing press in the exhibition, and 20 institutions responded to the questionnaire, which represents 80% of the research sample.

### 2-3. The Study Data Collection Tool

The researcher used the personal interview method, codified in a questionnaire, as a collection tool data.

### 2-4. The Study Procedures

2-4-1. Designing a simple questionnaire model after the institution's introductory questions, a set of options was analyzed from the theoretical study of how to take advantage of integrated technologies emerging from the fourth industrial revolution in the packaging industry as shown in the following questionnaire form.

**Which of the following technologies do you use or produce in your packaging system workflow in your company?**

		YES	NO	WHERE?
1	SIMULATION (3d printing)			
2	CAD / CAM SYSTEMs			
3	Artificial Intelligence in design Process			
4	Virtual & Augmented Reality			
5	Smart Packaging Products			
6	System Integration (production)			
7	Robotics			
8	Advanced Robotics			
9	Using cloud services			
10	M2M: machine-to-machine communications			
<b>Which Technologies in Your Company Are Driving Industry 4.0?</b>				1. 2. 3. 4. 5.

Table (1): Questionnaire for Egyptian packaging companies

### 2-4-2. Discussion and Results

The result that summarizes the answers is shown in figure (1)

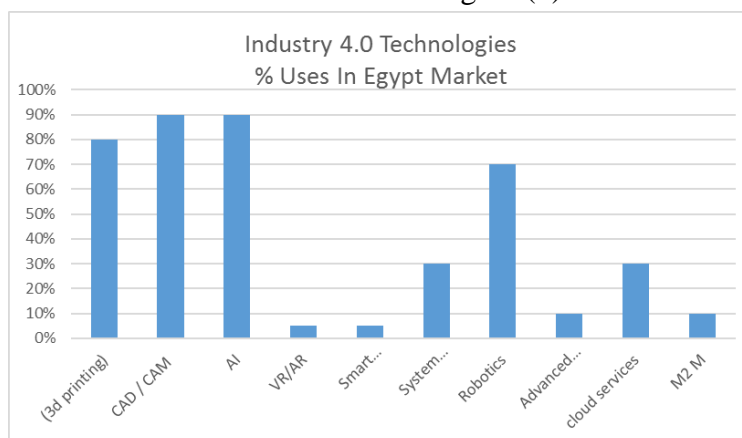


Figure (1): Result for Questionnaire

2-4-2-1. Non-integrated use of industry 4.0 technologies in the field of packaging in the Egyptian market.

2-4-2-2. The use of Artificial intelligence and computer-aided design is one of the most used techniques for the Fourth Industrial Revolution in Egyptian packaging institutions.

### 3- Methodology and Procedures

Depending on these results the Author used these Methodologies and Procedures.

An Analytical Study of Global Packaging Trends in Light of the Fourth Industrial Revolution and a Practical Study of the Impact of Artificial Intelligence as One of the Tools of the Fourth Industrial Revolution on the Packaging Designer.

In order to achieve the objective of the research, the research plan included the following Axes:

**First: Theoretical Study** for industry 4.0 and its impact on packaging.

**Second: Analytical Study** A suggested illustrative roadmap for how to take advantage of industry 4.0 packaging technologies.

**Third: Experimental Work** Using Artificial Intelligence in Packaging Design.

### Fourth: Results and Recommendation.

#### First: Theoretical Study

##### 1- Industry 4.0

New Emerged Technologies for the Internet of Things Connectivity, Cloud Computing, Artificial Intelligence (AI), Big Data, Quantum Computing, Prototyping by 3D Printing, and a Host of Other Emerged Technologies Together, These Technologies Inaugurated a Fourth Industrial Revolution That Called **Industry 4.0**. (4: page 16)

It is a new way to connect and communicate that links digital technology to People and objects, it will lead to greater efficiencies and change traditional productive relationships among suppliers, producers, and customers as well as between humans and machines, nine technologies are shown in Figure (2) trends form the building blocks of Industry 4.0.

(7: page 23)

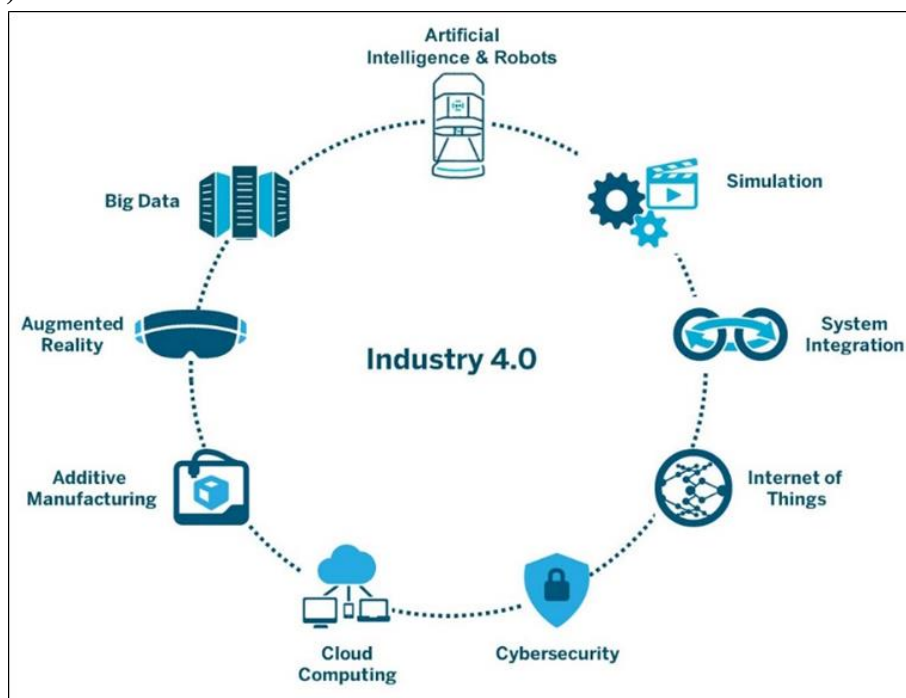


Figure (2): Emerging Technology for “Industry 4.0” (4: page 83)

The Packaging Industry Also Offers Numerous Opportunities to Drive Change to Packaging 4.0, But Not Only the Packaging Itself is Becoming More Digital, Efficiency and Productivity. The Production Process and the Entire Value Chain Are Also Developing Rapidly.

## 2- The Art and Science of Package Design

Packaging Requires the Expertise of Many Disciplines Are Shown in Figure (3) Marketing, Strategic Planning, Research, Psychology, Art, Industrial Design, Graphic Design, Logistics, Engineering, Production, Manufacturing, Distribution, and Retailing.

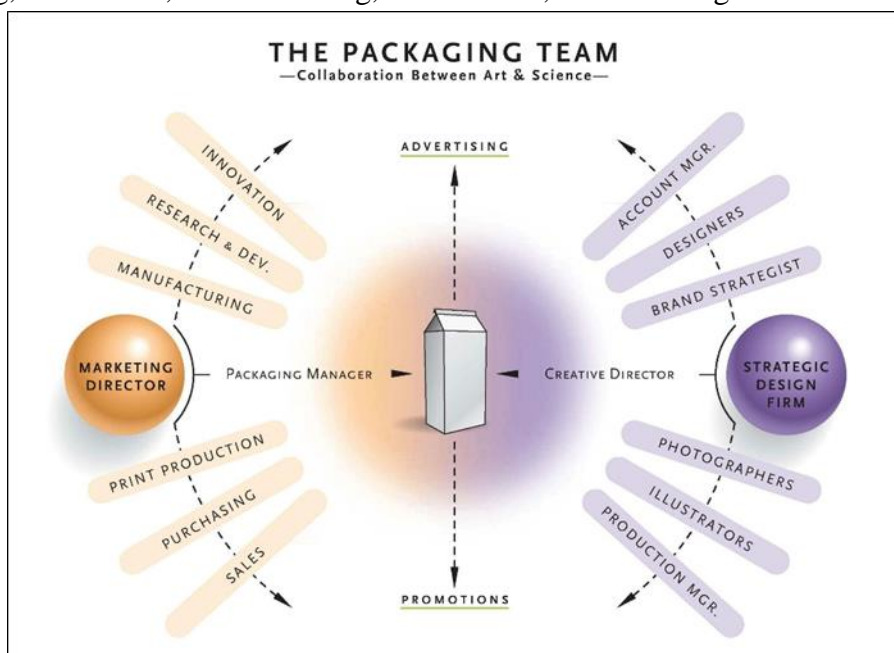


Figure (3): Art and Science in Packaging (1: page 38)

**2-1. “Packaging design** is the Connection of Form, Structure, Materials, Color, Imagery, Typography, and Regulatory Information with Ancillary Design Elements to Make a Product Suitable for Marketing”.

Its Primary Objective Is to Create a Vehicle That Serves to Contain, Protect, Transport, Dispense, Store, Identify, and Distinguish a Product in The Marketplace.

Ultimately, the Goal of a Packaging Design Is to Meet Marketing Objectives by Distinctively Communicating a Consumer Product’s Personality or Function and Generating a Sale. (1: page 32)

Designers and Clients Must Understand This Sequence and Apply It to The Way Consumers Will See Their Product Packaging; This Is the Order in Which Humans See:

1. Color.
2. Shape.
3. Photography.
4. Words.

## 2-2. Six Purposes of Packaging (9: page 42)

1. Containment.
2. Security.
3. Protection.
4. Convenience.

5. Information.

6. Marketing.

This Diagram in Figure (4) Shows a Simplified Overview of the Steps by Which a Package Goes from Concept to Completion.

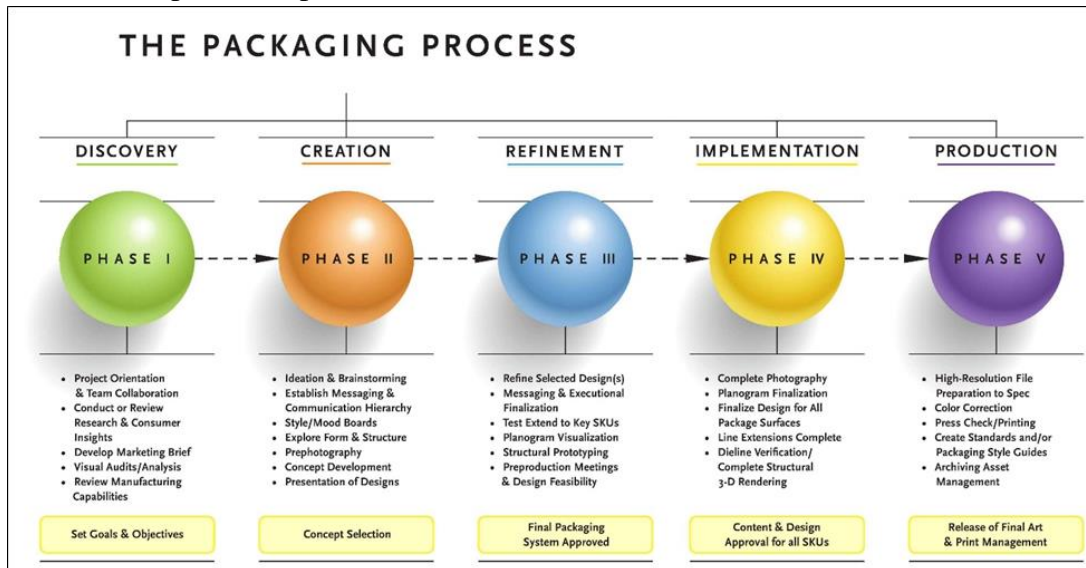


Figure (4): The Packaging Process (1: page 78)

**2-3. Packaging 4.0 and PackML (10)**

The Definitions of Packaging 4.0 are Established, They Will Set New Benchmarks for Operational Efficiency.

Packaging 4.0 Depend on Emerging Technology for “Industry 4.0”, Packaging 4.0 Will Enable a New Scale of OEE Optimization, Productivity, and Bring Uniform Measurement to Multivendor Environments.

Technologies Such as Predictive Maintenance, Remote/Onboard Diagnostics, Mechatronic Streamlining and Networked Safety Will Boost Reliability Through Packml. Packml, or Packaging Machine Language Is a Programming Standard Defined by the Organization for Machine Automation and Control (OMAC) Is Shown in Figure (5).

Primarily, The Packml Standard Is Used for Packaging Applications but Can Be Applied to Machines in any Industry, Including Pharmaceuticals, or Food and Beverage Manufacturing.

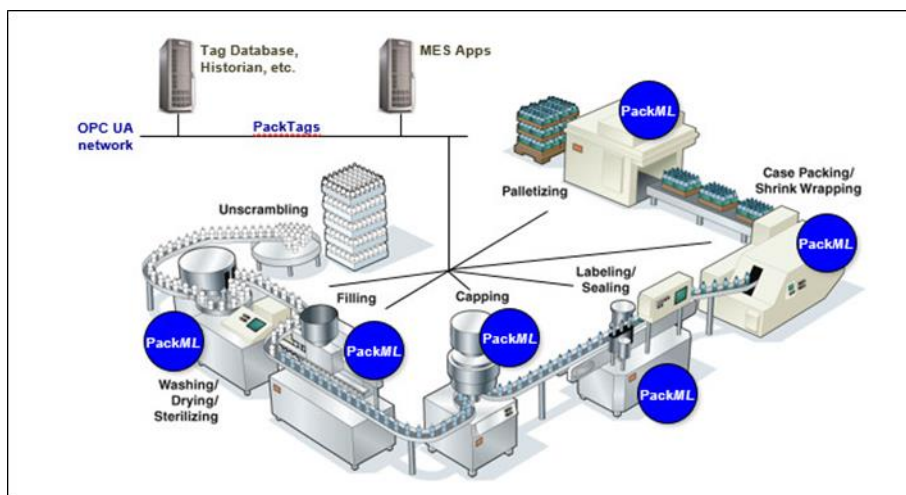


Figure (5): PackML Integration (11)



**2-4. Benefits of PackML. (3: page 32)**

- Increasing Interoperability and Lower Integration Costs (Easier Vertical and Horizontal Integration).

Makes It Easier for Machine Builders to Integrate Their Machinery into a Production Line.

- Higher Machine Performance.

Allows Systems Integrators to Use the Technologies They Know Best.

- Lower Training Costs and Fewer Operator Errors.

- More Productivity and Easier Maintenance.

- **Standardizing Overall Engineering Efficiency and Overall Equipment Effectiveness (OEE).**

- Faster Development and Debug Time

- Robust and Modular Software Programming.

- Easier Line Monitoring.

**2-5. Internet of Things (IoT) and Smart Packaging**

The effects of the Internet of Things (IOT) and the digital revolution can already be seen throughout the packaging industry.

After all, the packaging is an essential link between value chain participants as well as an interface between brands, retailers, and consumers.

For packaging to reach its full (IOT) potential, there must first be a secure, reliable, and accepted means of collecting and sharing data and resources up and down the entire value chain.

A product and its packaging are increasingly being perceived and treated as a single unit. As the (IOT) takes shape, this trend will continue to gain traction under the new revelation that called smart packaging. **(2: page 112)**

**2-6. Smart Packaging**

Smart and Active packaging can help monitor packaged goods and display or even regulate key conditions such as temperature and humidity as shown in Figure (6).

It can also facilitate compliance with medication prescriptions, display shelf life, make traceability more transparent and accessible, check inventory levels, and trigger re-orders.

Smart packaging and smart labels can steer the entire packaging process. IoT trends such as mass personalization and just-in-time manufacturing rely on packaging as a key player in the process. **(8: page 12)**





Figure (6): Smart Packaging

The global smart packaging market size was estimated at USD 6.65 billion in 2015, growing at a CAGR of 8.91% from 2016 to 2024 is shown in Figure (7). (6: page 21)

Rising use of smart packaging to increase the shelf life and traceability of food products is expected to witness the positive impact on overall industry growth in the forecast period.

Smart packaging is a combination of specialized materials, science, and technology that enhances the packaging functionality by implementing active and intelligent packaging in conventional packaging with the Internet of Things and Clouding Technologies.

It helps to prevent food spoilage, enhance food product attributes such as aroma, taste, and flavor, and also helps in brand protection, premium pricing, and waste reduction.

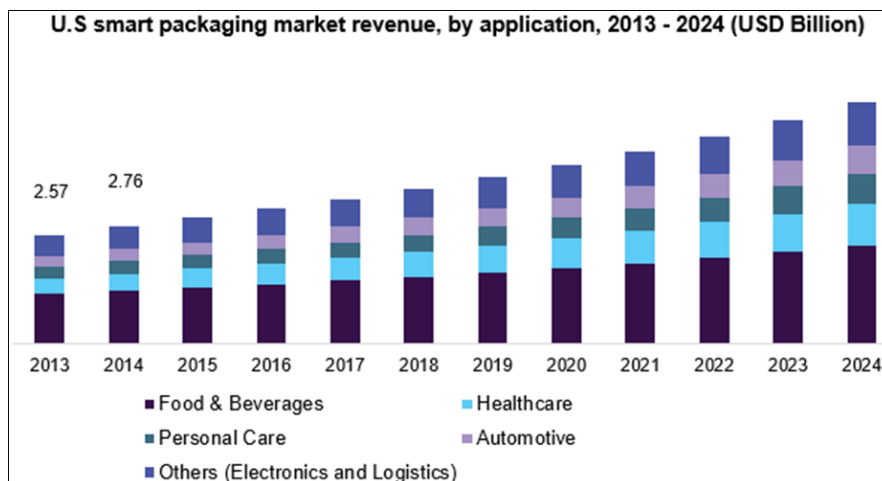


Figure (7): Smart Packaging Market in US (10)

### 2-7. Augmented Reality (AR) In Packaging (11)

VR is Computer-Generated Simulations of Real-Life Environments; AR is Real-World Capture of Physical Environments Which is Then “Augmented” By Computer-Generated Input.

The Motivation Behind This Innovation is to Offer Purchasers the Chance to Live a Vivid Encounter.

For Brands, It’s Another Method to Grab Consumers’ Eye Catch and Have the Effect in the Buy Choice Procedure.

Today, AR Takes Various Structures Software, Hardware, and Services, Which Give Companies a Wide Range of Possibilities, Brands Have Now Introduced Augmented Reality into Their Packaging to Keep Up or Even Make Another Connection with Customers’ Smartphones.

One of the First Brands to Have Played with the AR Technology Was McDonald’s as Shown in Figure (8).

They Have Taken the 2014 FIFA World Cup’s Opportunity to Launch Their AR Game. McDonald’s Switched Their Recognizable Fries’ Box for 12 Unique “World Cup-themed Arts.”



Figure (8): (AR) in Packaging by McDonald’s

This was created to work with the augmented reality app “McDonald’s GOL!”, which transformed the fries packaging into a net and football field.

This way, customers were able to virtually play football with their smartphone thanks to their fries’ box.

The functional use of packaging is now raised to an immersive and active experience.

### 2-8. Big Data, Clouding and System Integration (2: page 92)

Big Data Analytics Can Offer Excellent Opportunities to Create a Real Breakthrough in the Automation Plans with Particular Reference to Packaging Machinery Value Chain, Increasing Customization, Flexibility and Offering New Tools for Sustainability.

Big Data& Clouding and System Integration Through “IOT” Will Allow Proactive Monitoring of Product Quality and Predictive Maintenance, Enabling Decisions in Real Time, Allowing Also Manufacturers to Bridge the Gaps Left at the Design Phase of the Product.

### Second: Analytical Study

A suggested Analytical roadmap as shown in table (2) for how to take advantage of industry 4.0 technologies in Packaging based on analysis of theoretical study and Questionnaire.

Emerging Technology for “Industry 4.0”	Use Case in Packaging Process Work Flow	Value Add
IOT: Internet of Things	<ul style="list-style-type: none"> <li>• Smart Packaging Products.</li> <li>• Real Time Data Generation</li> <li>• In Line Quality Assurance.</li> <li>• Machine monitoring.</li> </ul>	<ul style="list-style-type: none"> <li>• Traceability and Consumer Information.</li> <li>• Vision Systems for Inspection.</li> </ul>
AI: Artificial Intelligence.	<ul style="list-style-type: none"> <li>• Design.</li> <li>• CAD – CAM.</li> <li>• Manage Intensive Data Processing.</li> </ul>	<ul style="list-style-type: none"> <li>• Personalized Design.</li> <li>• Sorting Recycled Goods.</li> <li>• Date Labeling (and other labeling solutions).</li> <li>• The Ability to Optimize and Speed Art Project Completions.</li> <li>• Provide Assistance to Designers Through Software Systems.</li> <li>• Develop the Ability of Reasoning in Designers.</li> <li>• Study and Analyze How Designers Work and How the Work-Flow Can Improve.</li> <li>• Guide Designers About How to Apply Artificial Intelligence Techniques to Solve Design Problems.</li> </ul>
VR&AR: Virtual & Augmented Reality.	<ul style="list-style-type: none"> <li>• Training.</li> <li>• Design &amp; Visualization.</li> <li>• Marketing.</li> </ul>	<ul style="list-style-type: none"> <li>• Provides the Consumer with More Information.</li> <li>• Improves Brand Loyalty.</li> <li>• Attracts More Customers.</li> <li>• Helps You Stand Out from the Competition.</li> <li>• It’s Easy to Use.</li> </ul>
SIMULATION.	<ul style="list-style-type: none"> <li>• 3d Printing.</li> <li>• Prototype.</li> </ul>	<ul style="list-style-type: none"> <li>• Proofing.</li> <li>• Endurance Tests.</li> </ul>

		<ul style="list-style-type: none"> <li>• Using Packaging Simulations in a Targeted way to Correct Incorrect Estimates and False Expectations Early.</li> <li>• <b>More Sustainable for Packaging Products.</b></li> </ul>
<b>System Integration.</b>	<ul style="list-style-type: none"> <li>• PackML.</li> </ul>	<ul style="list-style-type: none"> <li>• Increase OEE (Overall Equipment. Effectiveness).</li> <li>• Enables Predictive Maintenance.</li> </ul>
<b>Advanced Robotics.</b>	<ul style="list-style-type: none"> <li>• Complex Assemblies.</li> <li>• In line Quality Assurance.</li> </ul>	<ul style="list-style-type: none"> <li>• Detect Quality Defects.</li> <li>• Robots are far from Replacing All Manual Work in the Packaging. Industry.</li> </ul>
<b>Big Data Monitor.</b>	<ul style="list-style-type: none"> <li>• Data Profiling, Acquisition, and Transformation.</li> </ul>	<ul style="list-style-type: none"> <li>• Packaging Value Chain.</li> <li>• Improve Packaging Line Performance.</li> <li>• Improve Adaptivity, Reconfigurability and Flexibility, Even for Small Batches.</li> <li>• Reduce Operating and Maintenance Costs by Monitoring Technologies, Diagnostic, Prognostic, Also Remotely, And E-Maintenance.</li> <li>• Increase the Quality of Production and the Reduction of Waste.</li> <li>• Optimize the Use of Energy Resources and Take into Account the Complete Product Life Cycle and the Possible Industrial Symbiosis.</li> </ul>
<b>Cloud Computing.</b>	<ul style="list-style-type: none"> <li>• Data accessibility.</li> <li>• Integration with big data/AI.</li> <li>• A Warehouse Management Systems (WMS)</li> </ul>	<ul style="list-style-type: none"> <li>• Warehouse Management.</li> <li>• Logistics.</li> <li>• Secure Environment.</li> </ul>

Table (2): Roadmap for technologies of industry 4.0 in packaging

### Third: Experimental Work

The Combination of Artificial Intelligence (AI) and Computer-Aided Design Is Called AI – CAD Started Picking Up in Packaging Design Especially in Structural Design.

A Unique Set of Tools for 3D Packaging Design Made Specifically for Packaging Artwork Professionals and Build Packaging and Displays from Scratch or Generate Them with a Click of a Mouse.

AI - CAD Software Is Used to Increase the Productivity of the Designer, Improve the Quality, and Create a Manufacturing Database That Will Be Used Later with Packml System.

AI - CAD Output Is Often in the Form of Electronic Files Intended for Print, Machining, Or Other Manufacturing Operations with Packml System.

But Here, I Will Analysis Using Artificial Intelligence in Visual Design Packaging.

#### Analysis of Visual Label Designs Produced Using the Technique of Artificial Intelligence

The Maker of Nutella Has Employed an Algorithm to Design Millions of Unique Jars as Shown in Figure (9).

A Computer Program Was Provided with a Database of Bright, Bold Patterns and Colors That Were Judged Brand Appropriate. The Software Then Combined the Patterns and Colors to Generate Seven Million Different Designs to Print on Jars of Nutella Sold in Italy.



Figure (9): Nutella algorithm create 7000000 design.

### Analysis

- An Algorithm is A Program Developed to Execute Certain Functions, Nutella's Algorithm Would Combine Various Patterns and Colors for Each Design on Its Own and Then Give Each a Customized ID Code to Ensure That No Two Labels Were Alike.
- This Campaign Kept Nutella Logo, Layout and Typography but The Algorithm Pulled from a Database of Dozens of Patterns and Colors to Create Seven Million Different Versions of Nutella's Graphic Identity.
- Only Change Background, Dots, Stripes, Squares and Various Shapes Were All Fair Game When the Algorithm Went to Work as Shown in Figure (10).
- AI Is Not the Visual Designer's Enemy but A New Assistance Friend.

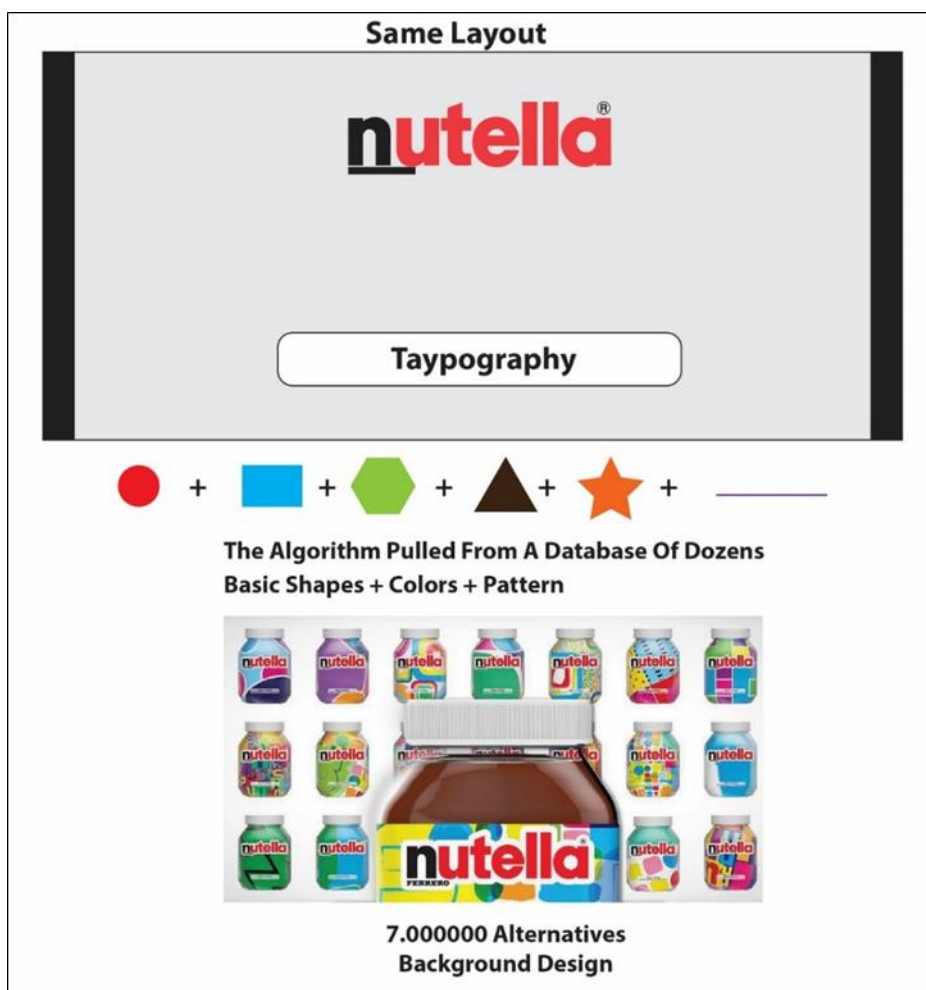


Figure (10): Nutella algorithm Analysis.

#### Fourth: Results and Recommendation.

##### Results

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## Recommendation

- 1- The Packaging 4.0 Industry Is Growing and Competition Is Intensifying Globally as It Is Considered the Mediator Between the Consumer and the Product.
- 2- Packaging Design Must Achieve the Ideal Balance Between Job and Design, In Light of Technical Constraints and Economic Feasibility, Which Requires the Packaging Industry in the Egyptian Market to Expand the Scope of Benefit and Integration of the Technologies of the Fourth Industrial Revolution.

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