

Computer Vision for Embedded Systems

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Goal: Create technologies to solve *real* problems that are worth your effort

Many technologists create "cool" solutions
without knowing the problems and needs.

Classroom Problems

- What is the problem \Rightarrow given by the professor
- Who cares about the problem \Rightarrow professor
- Why to solve the problem \Rightarrow to get points
- Where does the problem occur \Rightarrow classroom (?)
- When does the problem occur \Rightarrow before submission
- How to solve the problem \Rightarrow read textbook and handout

Why are problems' solutions already in textbooks?

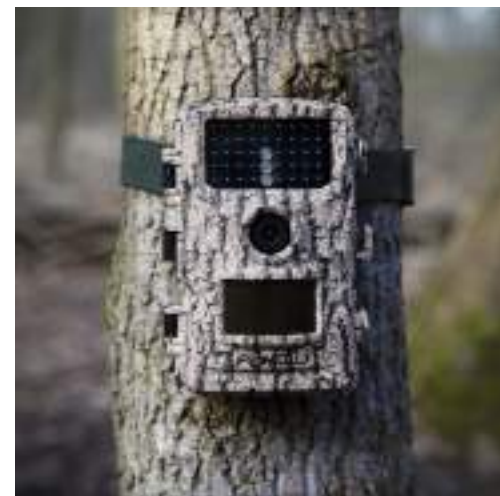
How can you solve real problems that are not in textbooks?

**Before you solve a problem, consider
whether the problem is worth solving.
Why do you want to solve it?**

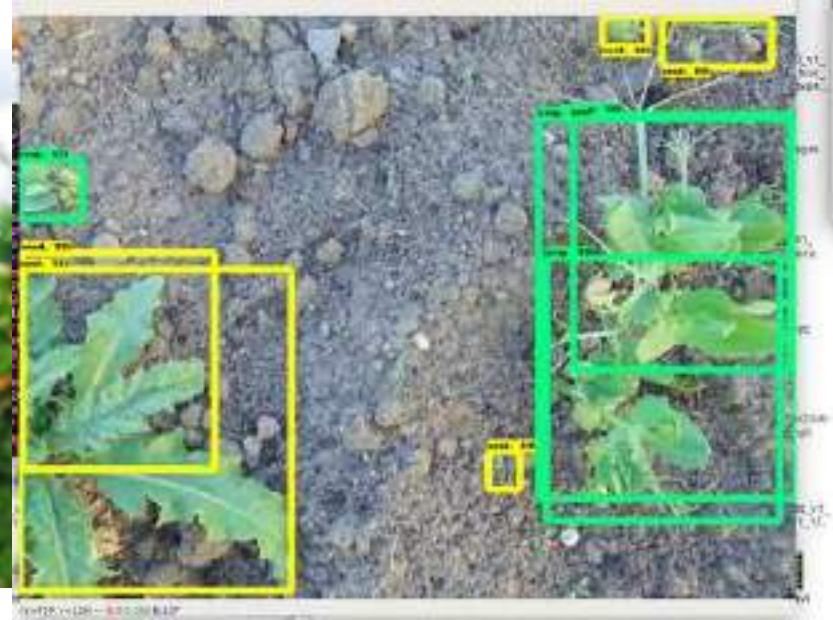
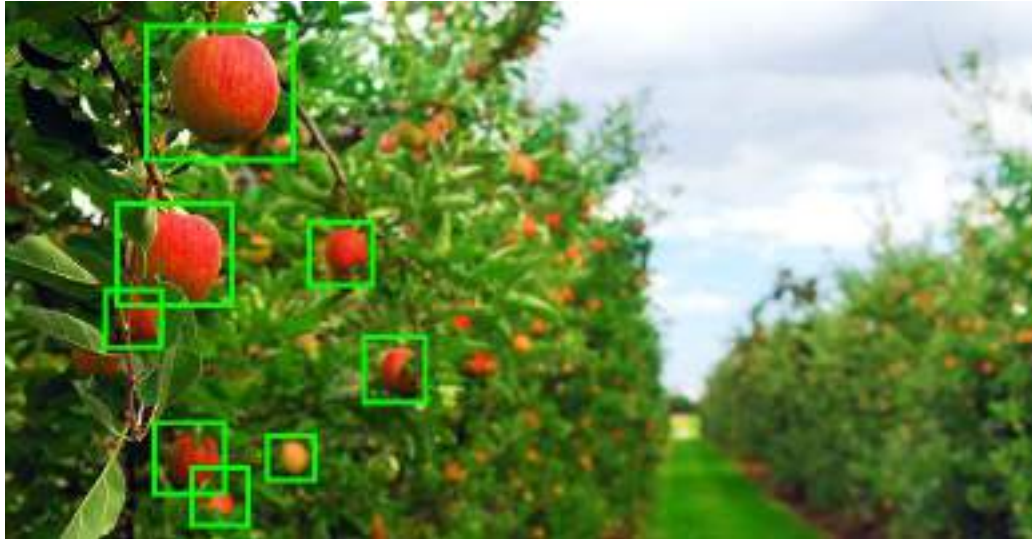
Do not waste time because "I want to learn."
Focus your effort for solving real problems.

Why discuss applications and businesses?

- How + Why + Who + Where + When ...
- Apply computer vision, machine learning, artificial intelligence in businesses
- Understand the business reasons (sometimes surprising to technologists)
- Develop the skills to create marketable technologies
- Avoid building technologies ***needed by nobody***
- Explore opportunities to commercialize technologies



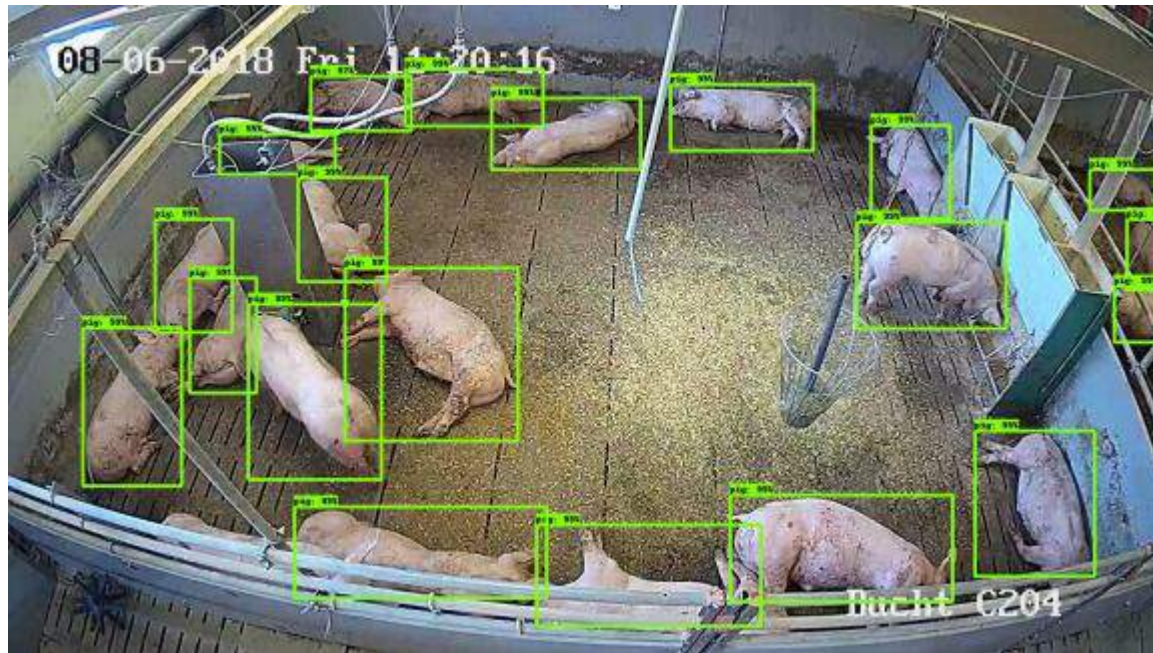
Computer vision in agriculture



<https://www.croptracker.com/blog/computer-vision-in-agriculture-part-1.html>

<https://link.springer.com/article/10.1007/s43154-020-00001-w>

Monitor farm animals



<https://www.sciencedirect.com/science/article/pii/S0168169918318283>

Transportation safety



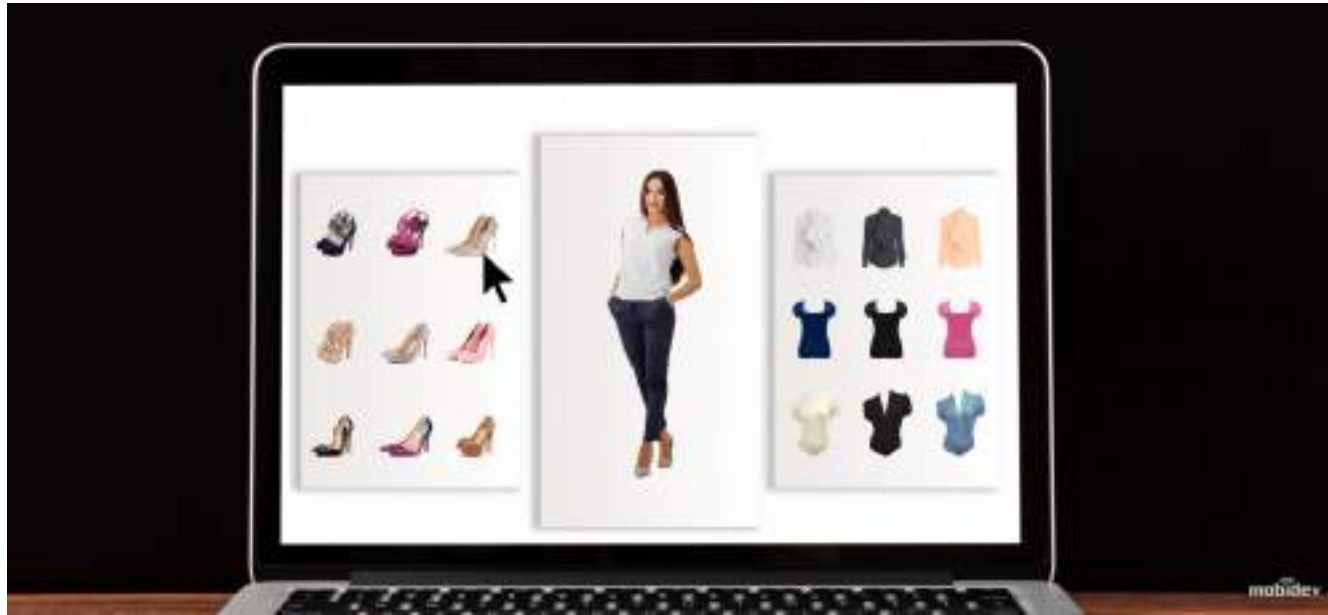
<https://medium.com/analytics-vidhya/introduction-to-computer-vision-with-opencv-part-1-3dc948521deb>

Work Safety



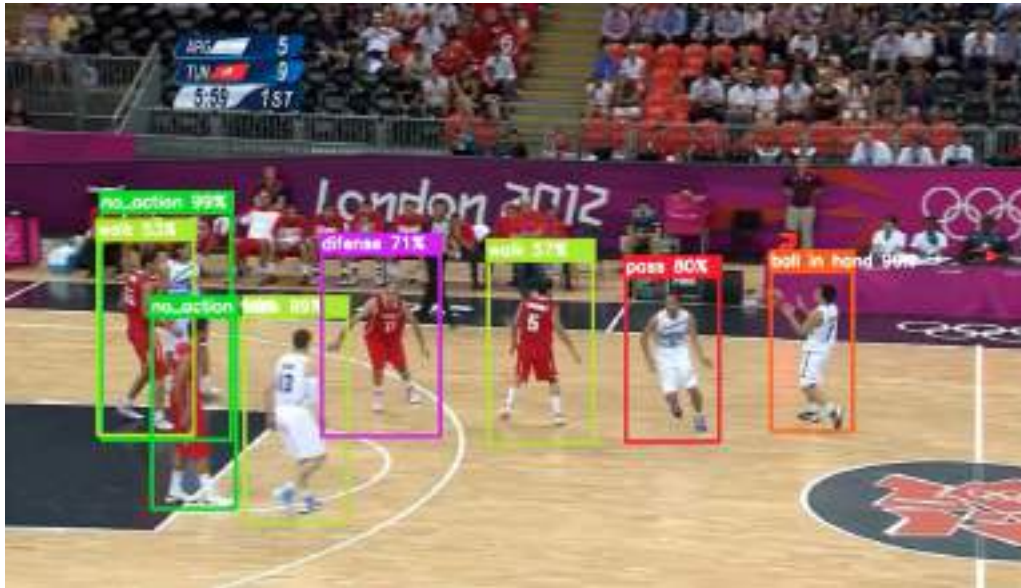
<https://blog.skyl.ai/workplace-safety-on-a-manufacturing-shop-floor-using-computer-vision>

Virtual fitting rooms



<https://mobidev.biz/blog/ar-ai-technologies-virtual-fitting-room-development>

Sports



<https://www.sportperformanceanalysis.com/article/computer-vision-in-sport>

<https://www.golfwrx.com/67315/golf-simulators-buying-guide/>



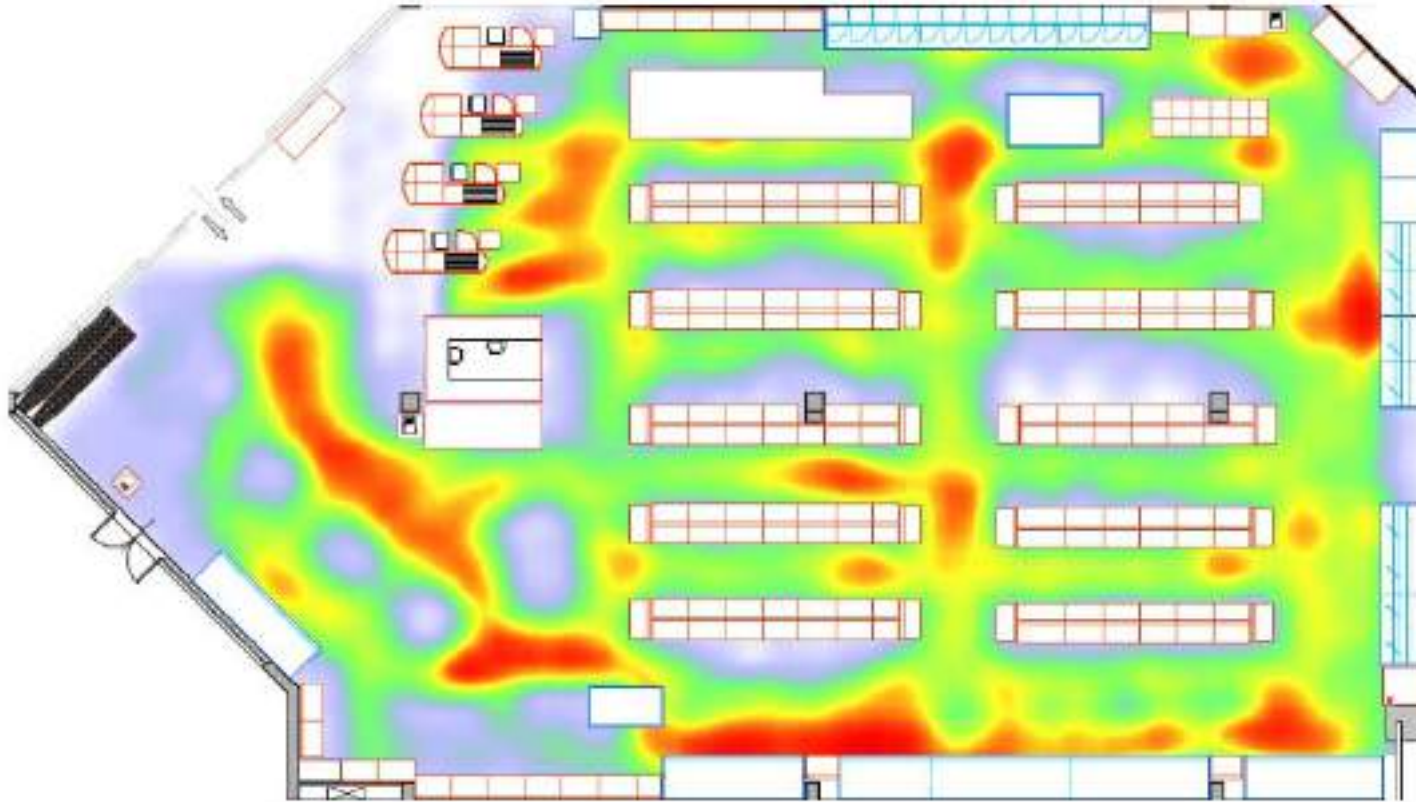
<https://www.aitrends.com/healthcare/machine-learning-advancing-medical-imaging-and-analysis/>

Inventory management



https://www.youtube.com/watch?v=B6zPnVGS0VI&ab_channel=PicaviGmbH

Space Utilization



<https://www.binaryversion.pt/retailerin/>

Yung-Hsiang Lu, Purdue University

Technologies and Businesses

PURDUE NSF I-CORPS



INTRODUCTION TO CUSTOMER DISCOVERY

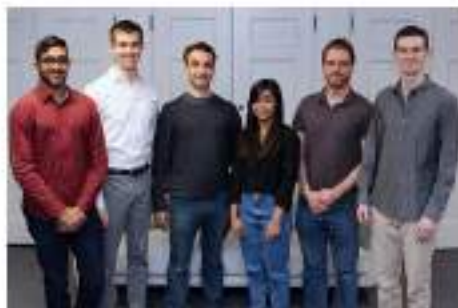
NSF Org:	TI Translational Impacts
Awardee:	PURDUE UNIVERSITY
Initial Amendment Date:	April 6, 2015
Latest Amendment Date:	April 6, 2015
Award Number:	1530914
Award Instrument:	Standard Grant
Program Manager:	Steven Konsek TI Translational Impacts TIP Dir for Tech, Innovation, & Partnerships
Start Date:	April 15, 2015
End Date:	September 30, 2016 (Estimated)
Total Intended Award Amount:	\$50,000.00
Total Awarded Amount to Date:	\$50,000.00
Funds Obligated to Date:	FY 2015 = \$50,000.00
History of Investigator:	Yung-Hsiang Lu (Principal Investigator) yunghu@purdue.edu

November 20, 2017

Purdue-based company developing software to improve customer service receives \$750,000 grant

WEST LAFAYETTE, Ind. – A company started by two **Purdue University** graduates to help high-end retail stores improve customer service through automated coaching of sales associates has received a two-year, \$750,000 federal grant to continue improving its software.

Perceive Inc., based in **the Anvil**, an entrepreneurial co-working space at Purdue, was awarded a National Science Foundation Phase II Small Business Innovation Grant. Perceive was previously awarded a \$225,000 Phase I SBIR



Perceive Inc. has received a \$750,000 National Science Foundation grant to continue to develop a business to help high-end retail



Research Foundation

- **Purdue, Rolls-Royce sign million strategic alliance**
- **Ag-Celerator fund invests NanoBio Designs, a gene**

Build a Business

- Understand the Lean LaunchPad concepts and tools such as customer discovery, value proposition design, and business model canvas
- Understand customers' problems (“pain points”) from ***their*** perspective
- Map your customer ecosystem to understand customer roles, requirements and decision processes
- Identify modifications to your technology assumptions to achieve product-market fit

Build a Business

- Build connections to the commercial ecosystem (i.e. customers, suppliers, partners, funders, accelerators ...) for your innovation
- Explore the size of your potential markets, assess the competition, and identify the first target market
- Develop a commercialization roadmap identifying key milestones and required resources to move forward
- Talk to alumni in the target market

Stop Thinking about "the idea"

- Many people think "the idea" is the most important thing. They are wrong.
- If you have only ideas, you have nothing. You need ways to realize (technologies) and protect (patents) your idea.
- Outsiders will not steal your ideas. Only your co-founders and employees can steal your ideas (+ technologies).
- Talk to as many people as possible. Get feedback and suggestions to improve your business.

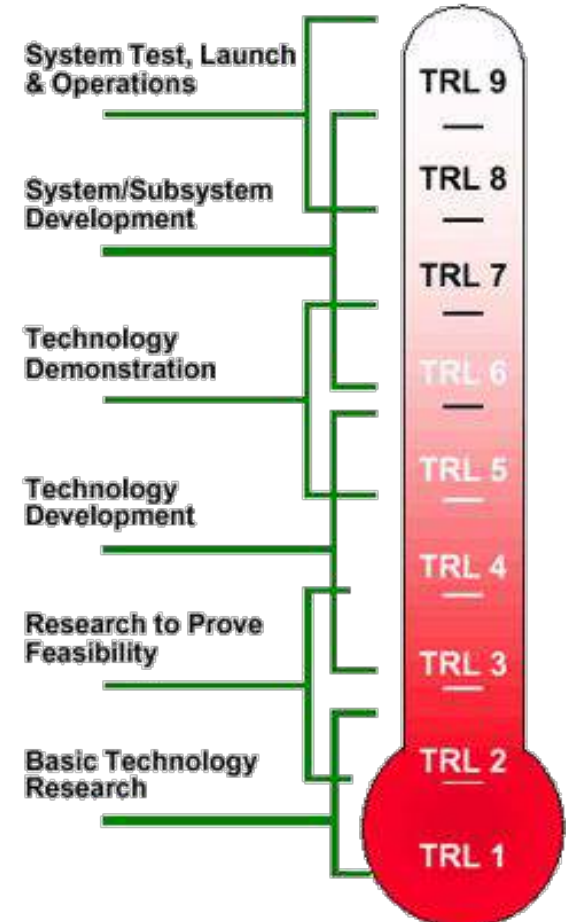
Semester Project

Design a *business* application using computer vision for embedded systems
Please read the assignment requirements for more details

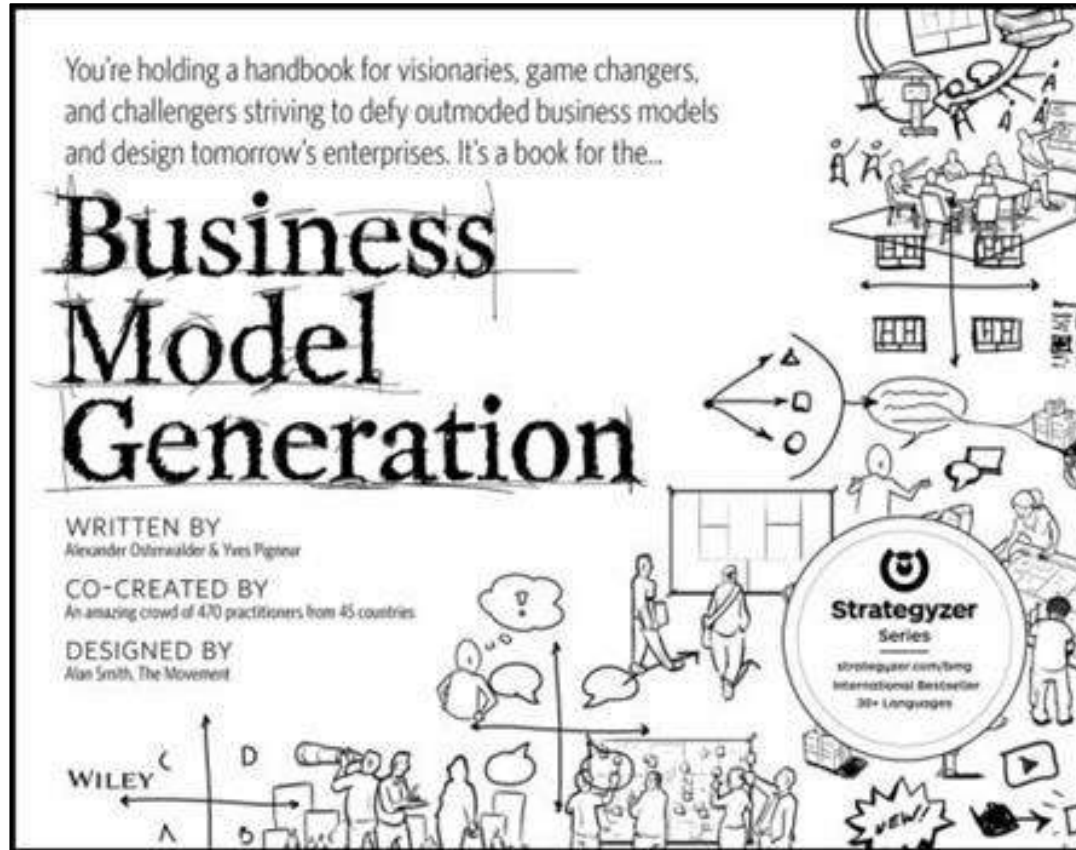
Technology Readiness Level 1-2

TRL created by NASA

1. Basic **principles** observed and reported
2. Technology **concept** and/or **application** formulated
3. Analytical and experimental critical function and/or characteristic proof-of concept
4. Component and/or breadboard validation in laboratory environment
5. Component and/or breadboard validation in relevant environment



9 essential questions for every business



Business Model Canvas

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segment
	Key Resources		Channels	
Cost Structure		Revenue Streams		

Common Mistakes

- I need an "idea" (a solution).
⇒ You need to identify an important problem.
- I am right. Everyone else is wrong.
⇒ You need to communicate with potential customers.
- If my product is better, it will sell well.
⇒ Need to know customers and incumbents' responses.
- I must be the first to succeed.
⇒ It is difficult to find customers if they do not understand

Common Mistakes

- I must move fast to succeed.
⇒ Flawed products may damage reputation and lose trust.
- I must raise money before I start.
⇒ It is difficult to raise money if you do not know customers.
- Money is the most important factor.
⇒ If you solve important problems, investors will come.
- If I win a business competition, I will be successful.
⇒ Winning is a good start, not an assurance of success.

Why do some people start businesses?

They want to *solve important problems* (important to themselves and the customers) *in unique ways* and starting new businesses is the *only* path forward.

Definitely *not* because of money, fame, freedom ...

Separate solutions from problems

A common mistake is to believe that your solution is the best or the only, while ignoring other possible solutions.

Problem	Possible solutions
transportation	rental car, uber, taxi, bus, bike, walk ...
communication	mobile phone, zoom, FedEx, post office ...
knowledge	universities, edX, Coursera, books ...

Identify Problems Worth Solving

Best Scenario: Eliminate problems not worth your time

Worst Scenario: Waste months (or years) on wrong problems



How to communicate with *potential* customers

Do's

- Start with Purdue alumni. Find alumni working on related topics and connect with them.
- Focus on understanding *problems they* face (*not* the problem you want to solve)
- Understand how the problems are solved now
- Identify the deficiencies of existing solutions
- Talk to everyone that may be involved (users, decision makers, suppliers, competitors ...)
- Ask additional names to talk to

Where to find people to talk to?

Don'ts

- Talk to your friends or family members (they will say you are perfect)
- Expect them to confirm your hypotheses
- Focus on users that have no authority making purchase decisions
- Assume users are buyers

Story of your solution

Create a storyboard

- Who are these people?
- What do they want?
- Why are their desires not fulfilled?
- How do they cope now?
- What can you do for them?
- How do you change their lives?
- What happens after that?
- If you have no story, you do not know what you are doing.



<https://www.artstation.com/artwork/ZQZ4R>

Deliverables

1. Proposal (week 2): business needs and proposed solution
2. Progress (week 3, optional): adjustment of proposal
3. Presentation (week 5): 10-minute video explaining the ***business*** needs. Do ***not*** focus on technologies.

Suggestions

- *Treat this as the beginning of your career.*
- *Discussions are essential.*
- Talk to as many people as possible outside this class.
- Join the Burton D. Morgan Business Model Competition.
- Purdue has many resources for commercialization.
- Focus on one key problem and think deeply. Don't try too many things superficially.
- Read books about successful businesses.

Check Companies in Industry Consortium





September 13, 2021

U.S. News rankings: Purdue again among top 10 'Most Innovative Schools' in nation



April 28, 2020

Purdue ranked 3rd nationally in startup creation

Want to an Entrepreneur?

Yung-Hsiang Lu

Professor, Electrical and Computer Engineering

Director, John Martinson Entrepreneurial Center



What problems do you want to solve?

- Explore space
- Eliminate diseases
- Protect environment
- Reduce poverty
- Save lives
- Improve Education

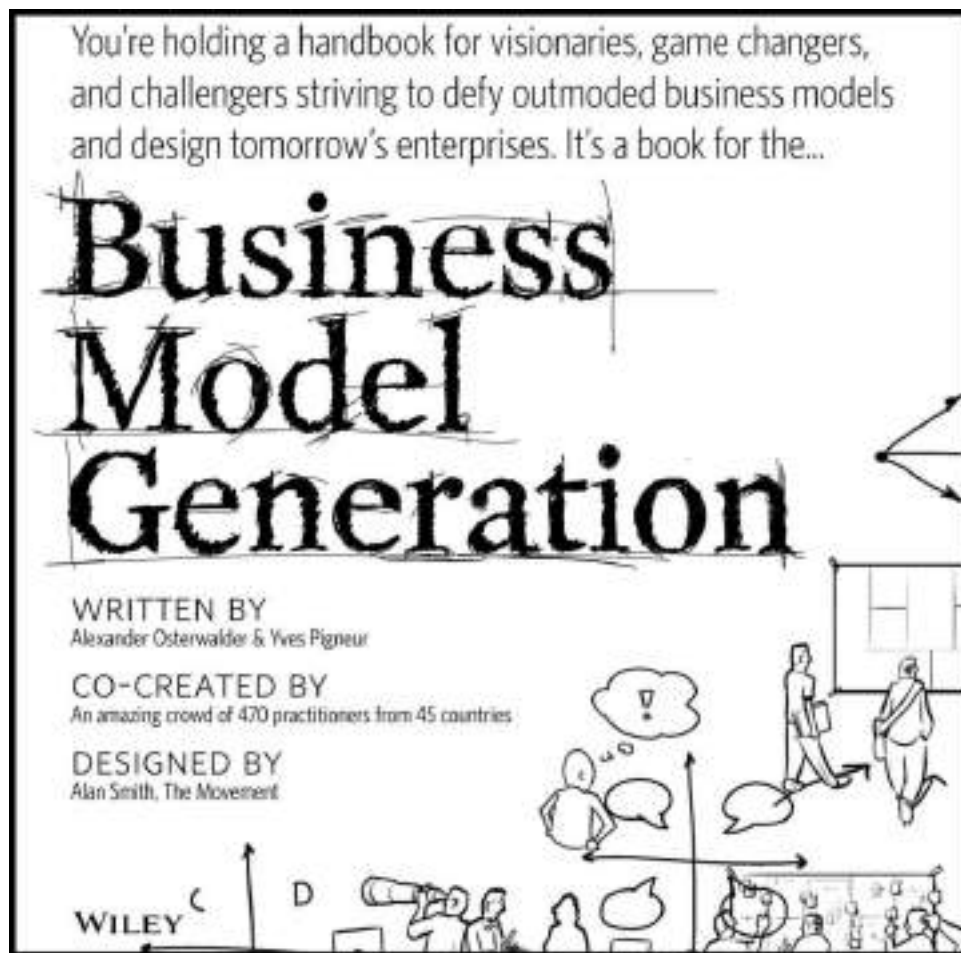
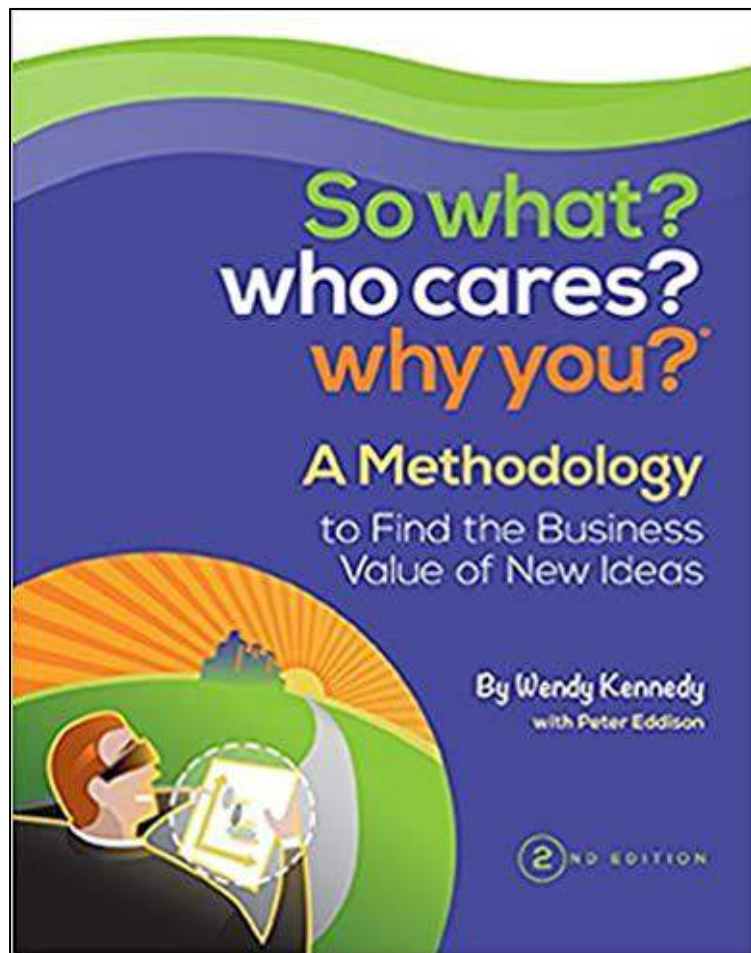


Secret of Success

- Decide what you want to accomplish in your life
- Identify the ways you can make the world better
- Manage your own career if you want to be happy

Most people:

- their lives are decided by their first managers
- 85% people are disengaged ("unhappy") from their jobs



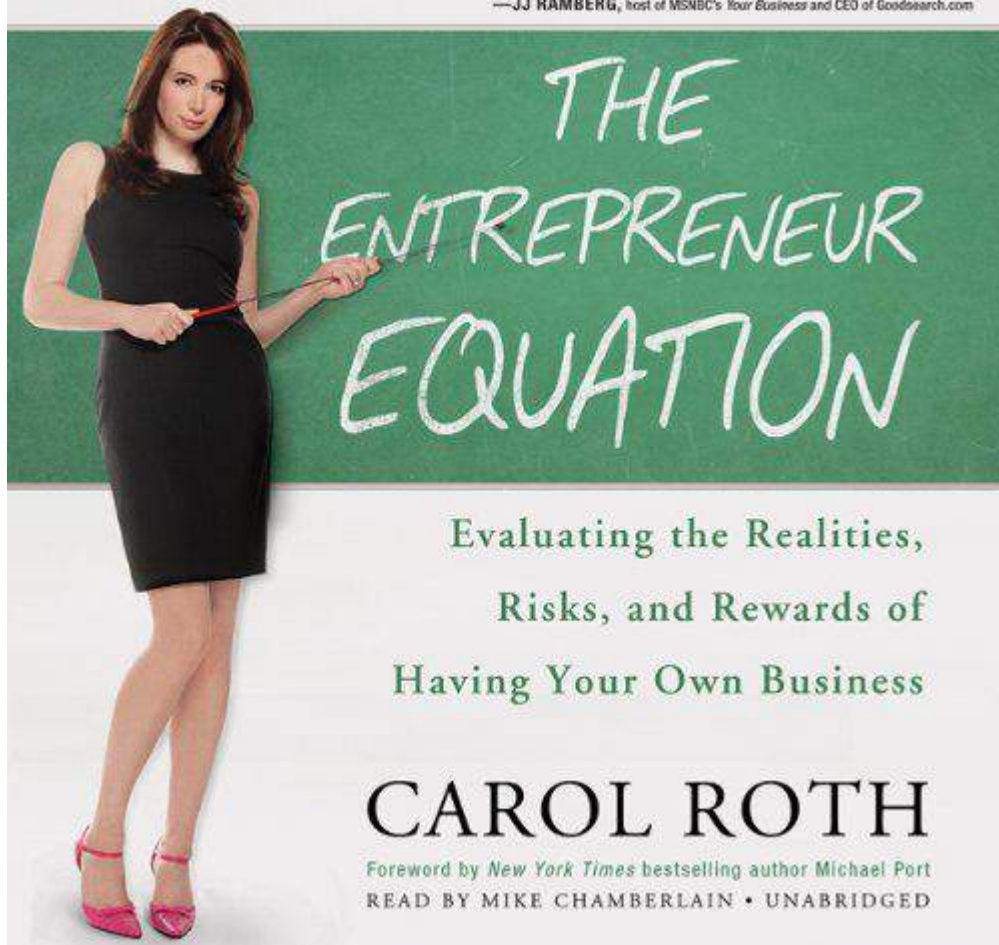
Problem of water shortage

Are you a water carrier or a pipe builder?



"Carol delivers the reality check that today's entrepreneur needs to succeed."

—JJ RAMBERG, host of MSNBC's *Your Business* and CEO of Goodsearch.com



Understand why some want to be entrepreneurs

Myth	Reality
Want to become rich	Want to solve people's problems
Become rich quickly	Many fail and become poorer
Flexible working hours	Very flexible, (almost) 24 hours
No boss	Customers, suppliers, employees, investors ... are all your bosses
Do only what I like	+ Finance + HR + Inventory + ...

**What is the No.1 factor for
successful entrepreneurs?
(from the survey of **entrepreneurs**)**

Team

T Together

E Everyone

A Accomplishes

M More



Failure before Success

- Michael Jordan, “I’ve failed over and over and over again in my life. And that is why I succeed.”
- Thomas Edison, “I have not failed. I’ve just found 1,000 ways that won’t work.”
- Steve Jobs, “If you really look closely, most overnight successes took a long time.”
- *Yung-Hsiang Lu*, “If you always succeed, you have failed because you never take challenges.”



Yung-Hsiang Lu, Purdue University

What Can You Do?



- Do research to create technologies
- Take intern positions
- Participate in Business Model competitions
- Read books, learn, and understand entrepreneurship
- Think about the problems you want to solve
- Make many friends, join clubs, **build teams**
- Develop skills in leadership, communication, management

You're holding a handbook for visionaries, game changers,
and challengers striving to defy outmoded business models
and design tomorrow's enterprises. It's a book for the...

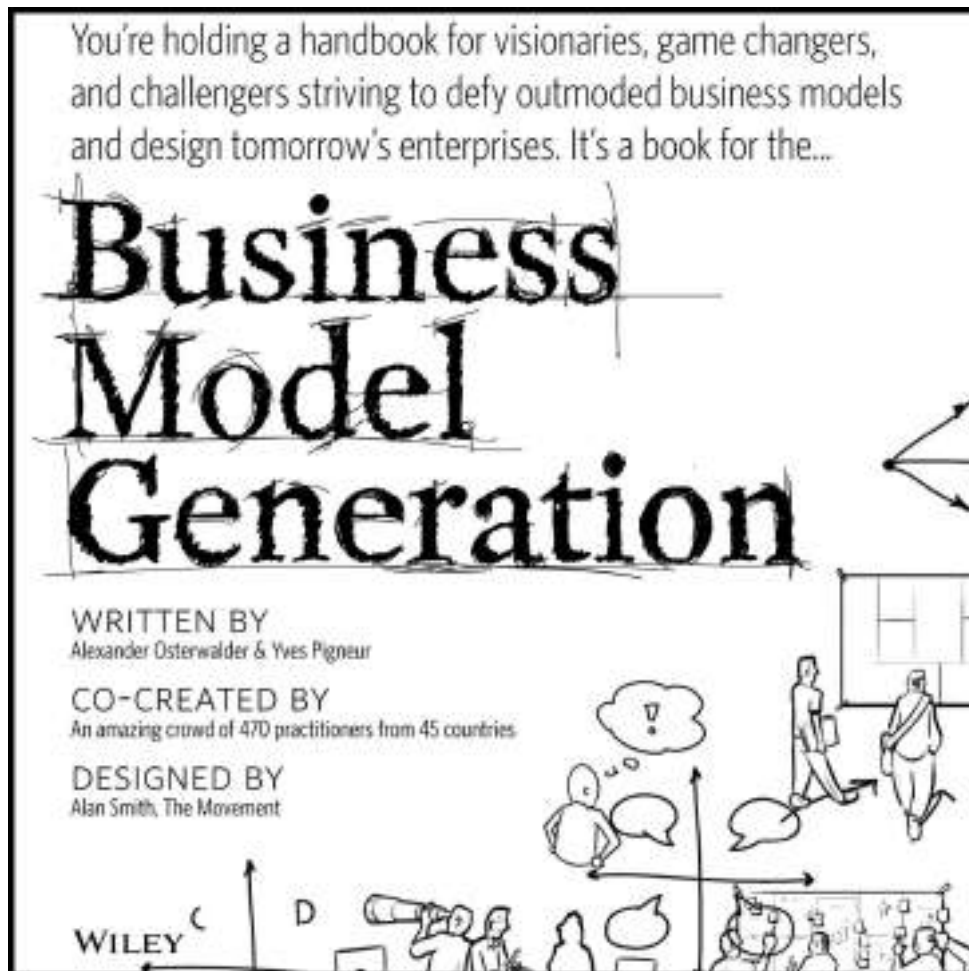
Business Model Generation

WRITTEN BY
Alexander Osterwalder & Yves Pigneur

CO-CREATED BY
An amazing crowd of 470 practitioners from 45 countries

DESIGNED BY
Alan Smith, The Movement

WILEY



A business model describes the rationales of how an organization creates, delivers, and captures value.

Value Propositions



What value do we deliver to the customer?

Which one of our customer's problems are we helping to solve?

What bundles of products and services are we offering to each Customer Segment?

Which customer needs are we satisfying?

CHARACTERISTICS

Newness

Performance

Customization

"Getting the Job Done"

Design

Brand/Status

Price

Cost Reduction

Risk Reduction

Accessibility

Convenience/Usability

**What do you offer?
Why are you special?**

Exercise: Value Proposition

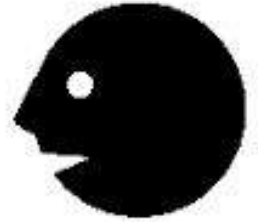
Answer four questions:

We (A: Product) for (B: Customer). We are better than (C: competitors) because (D: value proposition).

e.g., We sell sport cars to affluent customers. Ours are better than other sport cars because ours accelerate twice faster.

e.g., We sell everyday household products to price-sensitive customers. Our prices are consistently lower than others'.

Customer Segments



For whom are we creating value?

Who are our most important customers?

Mass Market

Niche Market

Segmented

Diversified

Multi-sided Platform

Who are the customers?

Channels



Through which Channels do our Customer Segments want to be reached?

How are we reaching them now?

How are our Channels integrated?

Which ones work best?

Which ones are most cost-efficient?

How are we integrating them with customer routines?

How do your customers get the products?

CHANNEL PHASES

1. Awareness

How do we raise awareness about our company's products and services?

2. Evaluation

How do we help customers evaluate our organization's Value Proposition?

3. Purchase

How do we allow customers to purchase specific products and services?

4. Delivery

How do we deliver a Value Proposition to customers?

5. After sales

How do we provide post-purchase customer support?

Integration of online and physical shopping



Amazon launches first-ever staffed campus pickup and drop-off location, Free One-Day Pickup services at Purdue

February 3, 2015



Revenue Streams

How do you make money?

For what value are our customers really willing to pay?

For what do they currently pay?

How are they currently paying?

How would they prefer to pay?

How much does each Revenue Stream contribute to overall revenues?

TYPES

Asset Sale

Usage Fee

Subscription Fees

Lending/Renting/Leasing

Licensing

Brokerage Fees

Advertising

FIXED PRICING

List Price

Product Feature Dependent

Customer Segment

Dependent

Volume Dependent

DYNAMIC PRICING

Negotiation (bargaining)

Yield Management

Real-time-Market

Key Partners



Who are our Key Partners?

Who are our Key Suppliers?

Which Key Resources are we acquiring from partners?

Which Key Activities do partners perform?

Who do you depend on?

MOTIVATIONS FOR PARTNERSHIPS

Optimization and economy

Reduction of risk and uncertainty

Acquisition of particular resources and activities

Cost Structure

Where do you spend money?

What are the most important costs inherent in our business model?

Which Key Resources are most expensive?

Which Key Activities are most expensive?

IS YOUR BUSINESS MORE

Cost Driven (leanest cost structure, low price value proposition, maximum automation, extensive outsourcing)

Value Driven (focused on value creation, premium value proposition)

SAMPLE CHARACTERISTICS

Fixed Costs (salaries, rents, utilities)

Variable Costs

Economies of Scale

Economies of Scope

Key Activities

How do your people spend time?

What Key Activities do our Value Propositions require?

Our Distribution Channels?

Customer Relationships?

Revenue Streams?

CATEGORIES

Production

Problem Solving

Platform/Network

Customer Relationships



What type of relationship does each of our Customer Segments expect us to establish and maintain with them?

Which ones have we established?

How are they integrated with the rest of our business model?

How costly are they?

EXAMPLES

Personal Assistance

Dedicated Personal Assistance

Self-Service

Automated Services

Communities

Co-creation

How do you acquire and retain customers?

Key Resources

How do you need to become (and remain) successful?

What Key Resources do our Value Propositions require?
Our Distribution Channels? Customer Relationships?
Revenue Streams?

TYPES OF RESOURCES

Physical

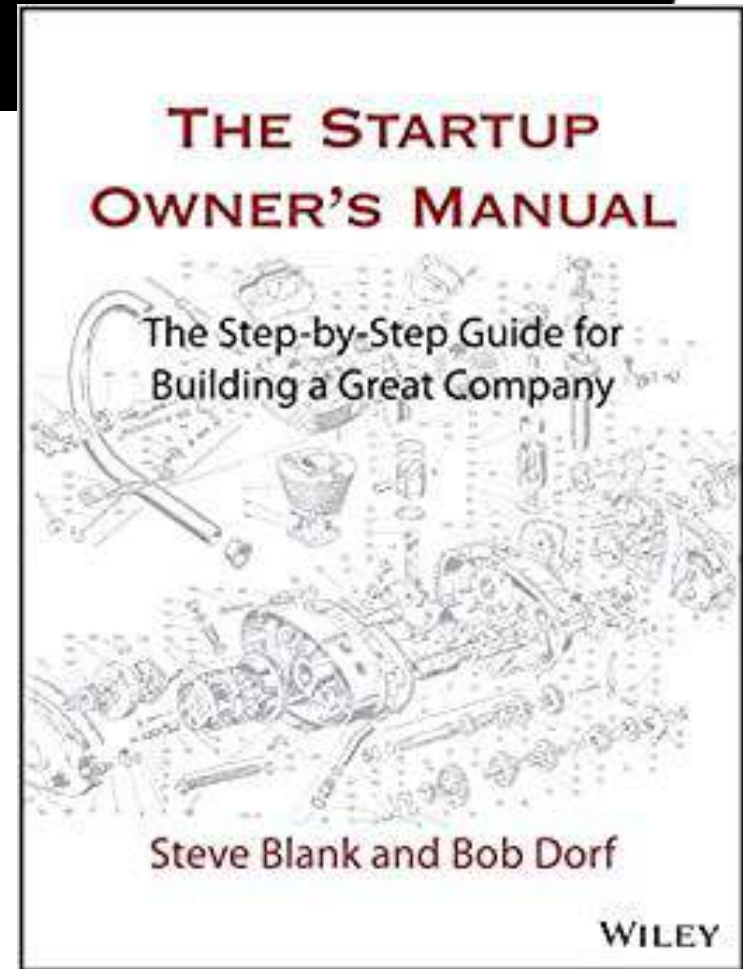
Intellectual (brand patents, copyrights, data)

Human

Financial

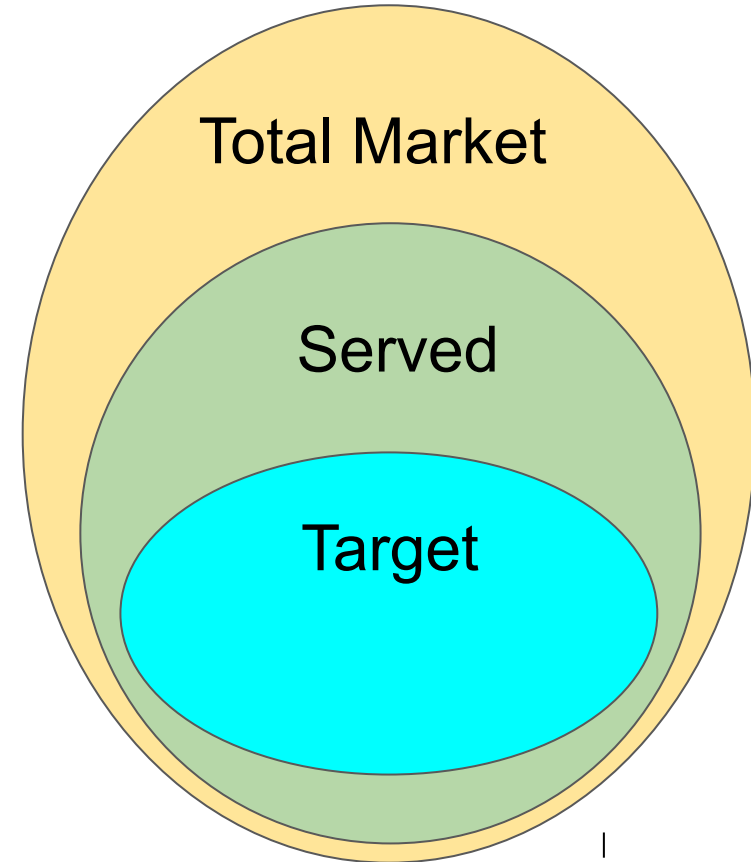
"Get out of the building. "Do people care?"

Do you want to build things that nobody, other than yourself, cares about?



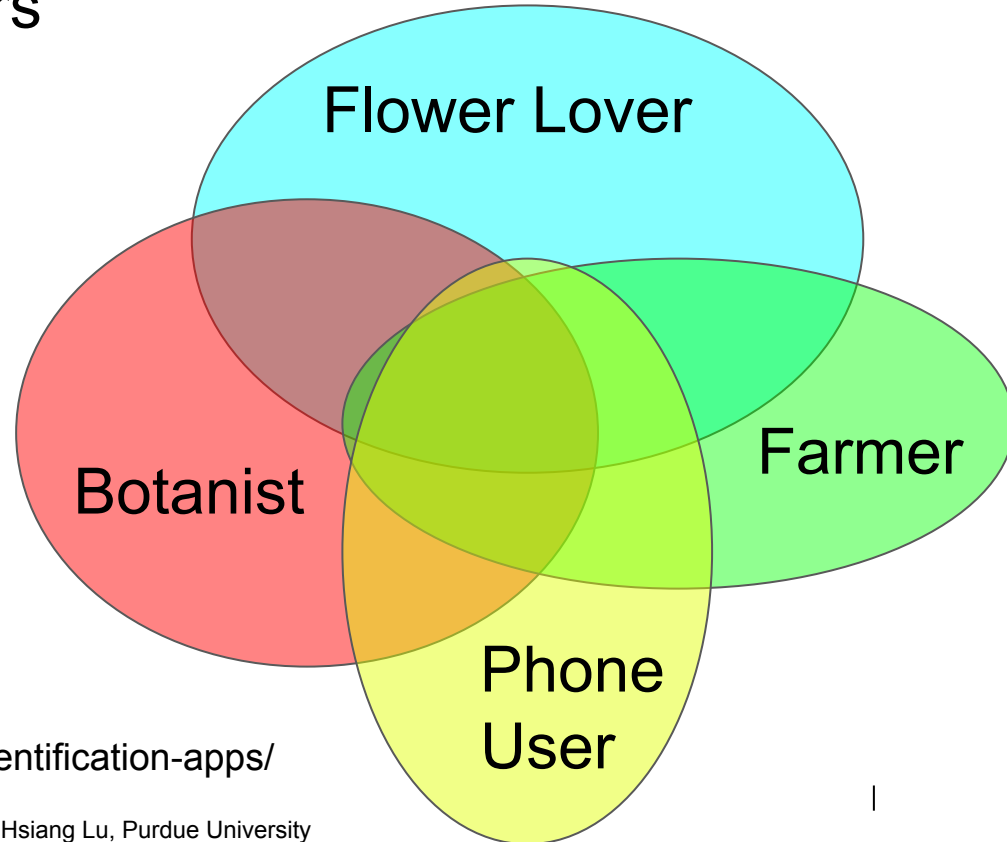
Understand Market

- Total: all possible customers
 - Served: existing customers
 - Target: customers to be acquired
-
- Will you buy your own products?
 - Some people say, "My customers are everyone on earth." Please name one company whose customers are everyone on earth.



Estimate Market for An App to Recognize Flowers

Paid app for recognize flowers



<https://theplantguide.net/2017/08/23/best-plant-identification-apps/>

Who will pay? Why?

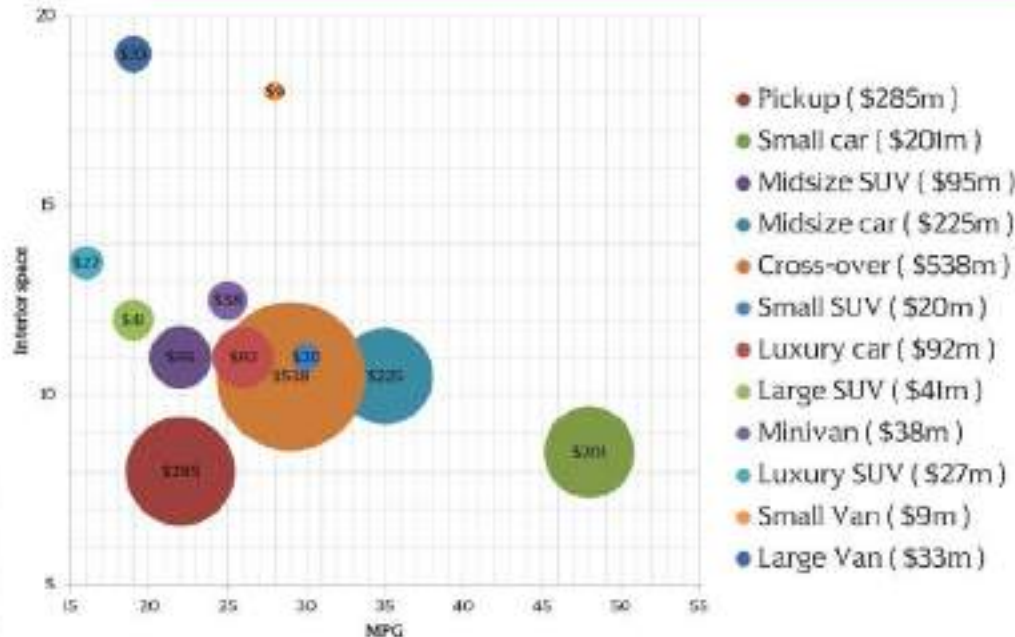
- Users
- Companies selling flower seeds
- Companies selling fertilizer
- National Park Services
- Environmental groups
- Tourist service
- Local governments

Where are customers?

- World
- USA + Canada
- USA
- Indiana + Ohio + Illinois + Michigan
- Indiana
- Tippecanoe County

Market for Electrical Vehicles

SJSU SAN JOSE STATE UNIVERSITY Market segmentation



<https://www.zdnet.com/article/electric-vehicles-are-the-future/>

<https://slideplayer.com/slide/14419978/>

Impacts of other customers

Do more customers attract more customers?

- unclear: brands of soap
- global: social networks
- local: restaurant

Is it "winner-take-all"?

- social networks
- online marketplace

Does your vision project have a market?

- Who are customers (the people that pay)?
- Who are the users? Are they customers? Why not?
- Who are your partners?
- Who do you rely on?

Talk to them. Validate your hypotheses.